EMU

ENGINE MANAGEMENT UNIT

USER MANUAL

ECU MASTER

www.ecumaster.com

ATTENTION !

- **ECUMASTER EMU can be used only for motor sports and cannot be used on public roads!**
- **The installation of the device can be performed only by trained specialists. The installation performed by an unskilled person may lead to the damage of both the device and the engine!**
- **Incorrect tuning of the engine with ECUMASTER EMU can result in a serious damage of your engine!**
- **Never modify the device's settings when the car is moving because it may cause an accident!**
- **Ecumaster company is not responsible for the damages caused by an incorrect installation or/ and tuning of the device!**
- **To ensure proper use of ECUMASTER EMU and to prevent risk of damage to your vehicle, you must read these instructions and understand them thoroughly before attempting to install this unit.**

IMPORTANT !

- **The manual below refers to the firmware version 0.986 of the ECUMASTER EMU**
- **Modification of the tables and parameters should be performed only by people who understand the working rules of the device and working rules of the modern injection and ignition systems.**
- **Never short-circuit the wires of the engine's wiring loom as well as the outputs of the ECUMASTER EMU device.**
- **All modifications of the engine's wiring loom must be performed with the disconnected negative terminal of the battery.**
- **It is very important that all connections in wiring loom should be properly insulated.**
- **All signals from the variable reluctant sensors and knock sensors should be connected using shielded cables.**
- **The device must be disconnected during welding of any car body elements!**

TABLE OF CONTENT

ECUMASTER EMU DEVICE

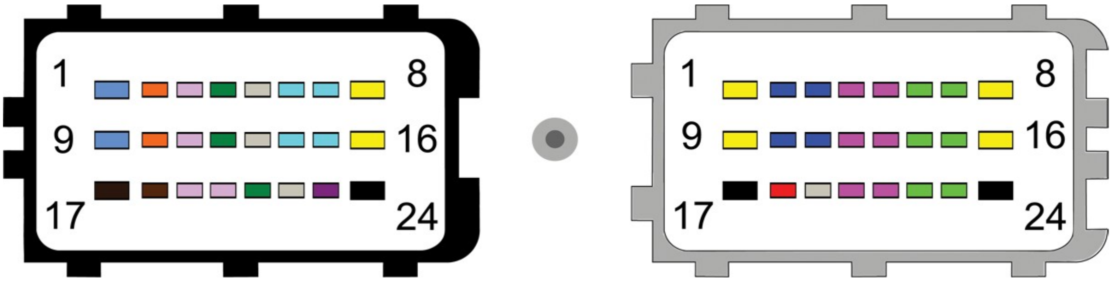
ECUMASTER EMU device is fully programmable, universal engine management unit for controlling spark-ignition engines using Speed Density or Alpha-N algorithms, using wide range of fuels (PB/E85/LPG/CNG). Due to utilizing modern technology and state of the art software, device can fully control fuel mixture using closed loop feedback based on wide band oxygen sensor, is capable of fully sequential injection and ignition, and can sense engine knock what allows optimal ignition advance.

ECUMASTER EMU supports wide range of OEM sensors (IAT, CLT, MAP, KS, etc). It has also lots of features used in motor-sports like gear dependent shift-light, flat shift, launch control, NO2 injection control, advanced boost control, and much more.

SPECIFICATION		
1	Power supply	6-20V, immunity to transients according to ISO 7637
2	Current requirement	400mA
3	Operating temperature	-40 do 100˚ C
4	Supported number of cylinders	1-6 – full sequential injection and ignition 1-12 - wasted spark
5	Max supported RPM	12000
6	Injection time	0.1ms – 50ms, resolution 16us
7	Ignition timing	60˚ BTDC – 20˚ ATDC,resolution 0,5˚
8	Injectors outputs	6 protected outputs, max. current 5A
9	Ignition outputs	6 outputs, max. current 7A, software selectable passive / active coils
10	AUX outputs	6 protected outputs, max. current 5A
11	AUX / Stepper	4 outputs,max. current 1A
12	Lambda sensors	- narrow band 4 wires sensor, - wide-band sensor Bosch LSU 4.2
13	Knock sensing	2channels, knock resonant frequency 1-20kHz
14	Crank / Cam signal (primary trigger)	VR sensor (adaptive input), HALL / Optical, software configurable
15	CAM sensors	2 inputs, VR or HALL / Optical software configurable
16	VSS	VR or HALL / Optical software configurable
17	EGT	2 channels, K-Type thermocouples
18	Analog inputs	7 protected analog inputs for sensors TPS, IAT, CLT, etc.
19	Additional outputs	Extension port: CANBus, DataLoger, Bluetooth, etc.
20	Other	Built in 400 kPa MAP and Baro Sensor
21	Communication	USB port
22	Client software	Windows XP, VISTA, Windows 7

FUNCTIONS		
1	Fuel calculation algorithm	Speed Density or Alpha-N
2	Fuel Table	16x16, resolution 0,1% VE
3	Injectors configuration	Phase and injection angle, injectors dead time calibration(16x1), injector flow rate configuration
4	AFR Table	16x16, resolution 0.1 AFR, closed loop feedback
5	Ignition triggers	12 – 60 primary trigger tooth , 0-2 missing tooth, 1 tooth cam sync synchronization
6	Ignition table	16x16, resolution 0,5˚
7	Ignition coils dwell	Dwell time table (16x1), dwell correction table in function of RPM (16x1)
8	Ignition advance corrections	Correction in function of CLT and IAT (16x1), per cylinder correction
9	IAT, CLT sensors	Calibration table (20x1), sensors wizard
10	Cranking fuel table	Table 16x1
11	Enrichments	ASE, Warmup, Acceleration, Deceleration
12	Knock sensing	Resonant frequency, knock window, knock actions like ignition retard, fuel mixture enrichment
13	Idle control	PID based control over stepper motor or idle vale. Ignition angle control. Idle Target table (16x1)
14	Parametric outputs	Fuel pump, radiator fans, tachometer, user defined
15	Boost control	PID base, DC table 16x16, Boost target, Gear and speed dependent
16	Sport functions	Launch control, Nitrous injection, flat shift, gear dependent shiftlight, etc.
17	Others	Check Engine light, fail save values for sensors, password protection
18	Log functions	Logging over 100 parameters, real time view

CONNECTOR PINOUT DETAILS



Device View

BLACK		GRAY	
1	EGT In #1	1	Ignition coil #6
2	Knock Sensor In #1	2	Stepper motor #1 winding A
3	Analog In #2	3	Stepper motor #2 winding A
4	CLT In	4	AUX 6
5	WBO Vs	5	AUX 3
6	Camsync In #2	6	Injector #4
7	Primary trigger In	7	Injector #1
8	Ignition coil #5	8	Ignition coil #1
9	EGT In #2	9	Ignition coil #3
10	Knock Sensor In #2	10	Stepper motor #1 winding B
11	Analog In #3	11	Stepper motor #2 winding B
12	TPS In	12	AUX 5
13	WBO Ip	13	AUX 2
14	VSS In	14	Injector #5
15	Camsync #1	15	Injector #2
16	Ignition coil #4	16	Ignition coil #2
17	ECU Ground	17	Power Ground
18	Sensor Ground	18	Power +12V
19	Analog In #4	19	WBO Heater
20	Analog In #1	20	AUX 4 / Tacho
21	IAT In	21	AUX 1
22	WBO Vs/Ip	22	Injector #6
23	+5V supply	23	Injector #3
24	Power Ground	24	Power Ground

SOFTWARE

Client for Windows

Communication with ECUMASTER EMU device is performed using USB AA cable, and Microsoft Windows based client software. Client allows to modify all settings (parameters, tables) stored in internal device flash memory as well as gathering real time data from engine sensors. Software is included on CD included in the package. For the latest software please visit www.ecumaster.com web page.

Firmware

Firmware is an internal EMU software that controls all aspects of device behavior. Due to the fact that device firmware can be upgraded, in future there will be new device functions available. It is required to use latest client software with new firmware. The client software is compatible backwards, what means that all previous firmware will work correctly. However the old client will not work with new firmware (appropriate message will be shown). Firmware is always included with client software package and can be download from www.ecumaster.com.

Software versions

Main software version is the first digit. The subversion is defined by 2 digits after the dot mark. The third digit means that there are only changes in windows client software and there is no firmware update. For example 1.01 means 1st main version with first software and firmware modification, 1.013 means first firmware update and fourth modification of Windows Client.

Software installation

Windows client installation version is included on ECUMASTER CD or can be downloaded form www.ecumaster.com. To install client insert CD into drive and choose appropriate button or run *EmuSetup_xxx.exe.* The software is compatible with the Windows XP, Vista and Windows 7.
It might be also required to install USB drivers that are also included on ECUMASTER CD.
If you have any problems with software installation please contact our technical support at schematy@ecumaster.com

Firmware upgrade

To upgrade firmware please choose option *Upgrade firmware* from *File* menu. After selecting proper firmware version press *Open* button. The upgrade should begin immediately. Do not turn of the device during firmware upgrade! When upgrade is finish turn off the device. The process is finished. All parameters and tables are automatically imported.

If the upgrade process fails, turn off device, turn it on, and make the following procedure again.

Attention !

In case of firmware upgrade failure the project should be saved on a disc before updating!

Attention !

Firmware upgrade should not be performed if there are problems with the communication between the device and PC computer!!!

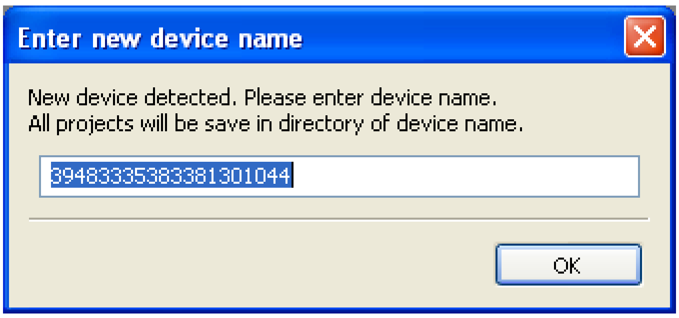
Attention !

Before you prform firmware upgrade, please disconnect injectors and ignition coils !

First connection

During first connection to the EMU device, there will appear a window with the device name.

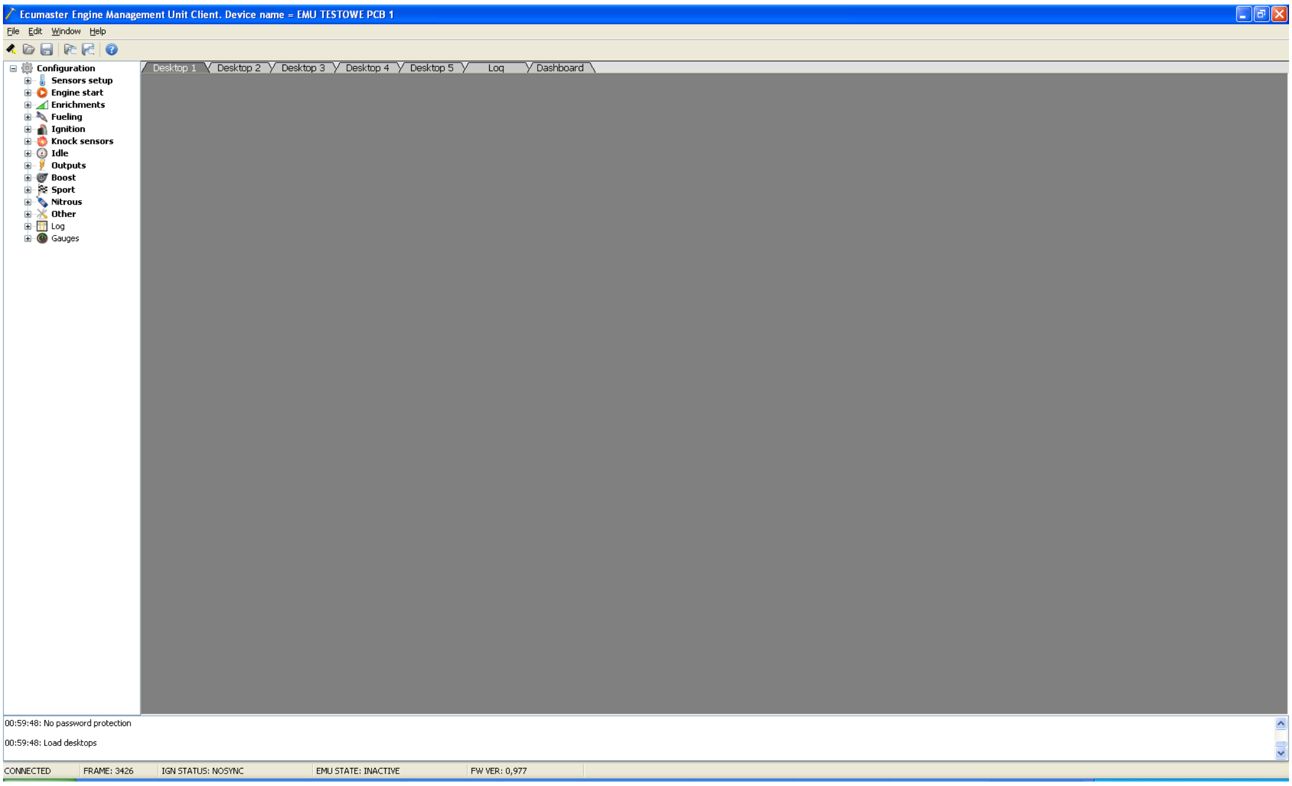
By default there will be device unique serial number what user can change for any name. Based on this name there will be sub-directory created in directory My documents / EMU. In this sub-directory there will be stored desktop configuration for given EMU, and projects and logs will be saved.



Projects extension is *.emu. Data logs are saved with extension *.emulog. User desktops configuration is stored in file *desktops.xml*. If no EMU device is connected all data is stored in *Default* sub-directory.

User interface

The picture below shows Windows client after first launch.



User interface is divided into 4 areas:

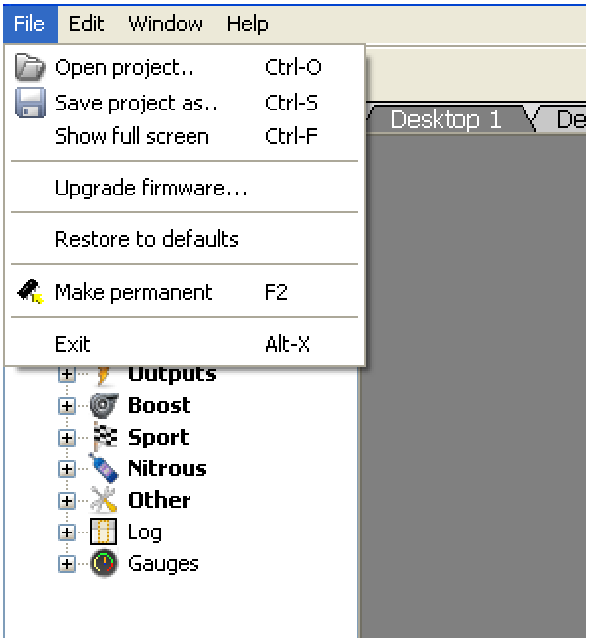
1. Menu
2. Tree view with device functions (you can hide / show it with key F9)
3. Desktop
4. Event log (you can hide / show this area by keys combination SHIFT + F9)

Menu

A menu bar consists of functions the following items:

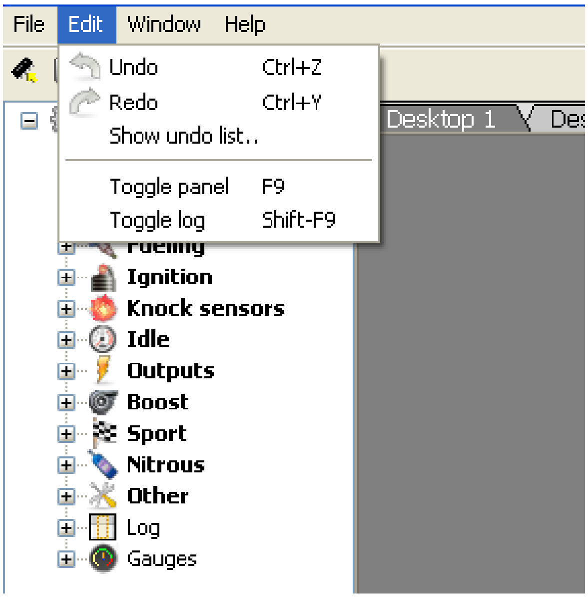
- **File**
- **Edit**
- **Window**
- **Help**

Menu FILE



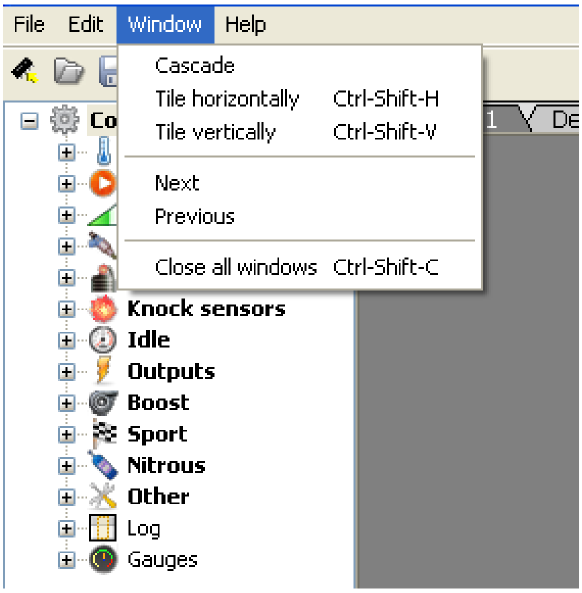
Name	Function
Open project	Open emu project files (*.emu)
Save project as	Save current project to disc
Show full screen	Enter full screen mode (to leave full screen press CTRL+F)
Upgrade firmware	Upgrade device firmware
Restore to defaults	All tables and paramters will be restored to factory defaults
Make permanent	Save all tables and parameters into internal DataFlash
Exit	Exit to Windows

Menu EDIT



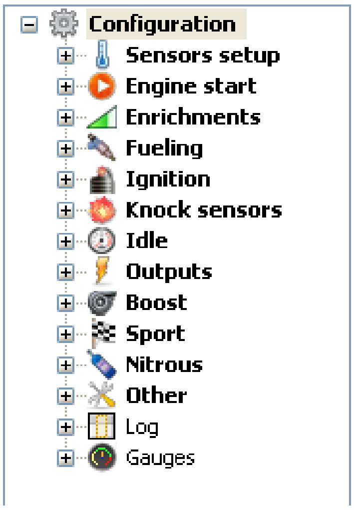
Nazwa	Funkcja
Undo	Undo last operation
Redo	Redo last undo operation
Show undo list	Show list of operations
Toggle panel	Toggle tree view panel
Toggle log	Toggle event log windo

Menu Window



Name	Function
Cascade	Cascades all open windows
Tile horizontally	Tiles all windows horizontally
Tile vertically	Tiles all windows vertically
Next	Switch to the next open window
Previous	Switch to the previous open window
Close all windows	Close all open windows
Open windows list	List of all windows on desktop

Functions tree view



On the left there is a list of all available EMU functions grouped in functional blocks. Depending on firmware version there could be different set of functions. By expanding functional group user can access parameters and tables.

Category *Sensors setup* contains all options required for calibrating engine sensors as well as fail safe values.

Engine start category groups all function and tables used during engine cranking. *Enrichments* group is responsible for all mixture enrichments, and categories *Fueling* and *Ignition* respectively for fuel dose and ignition angle. Category *Knock Sensor* contains functions required for knock sensor configuration, category *Idle* is responsible for controlling engine's idle speed. To configure AUX outputs (eg. Fuel pump, coolant fan, PWM outputs) category *Outputs* needs to be used. Category *Boost* controls boost pressure, *Sport* contains functions used in motorsport, *Nitrous* is responsible for nitrous oxide systems. For logging data and visaul representation of EMU parameters categories *Log i Gauges* should be used.

Desktops

There are 7 desktops in the Windows Client. On each desktop user can place tables, parameters blocks, gauges, etc. Desktops layout is assigned to the specific EMU device and is stored on disk when the windows client is closed.

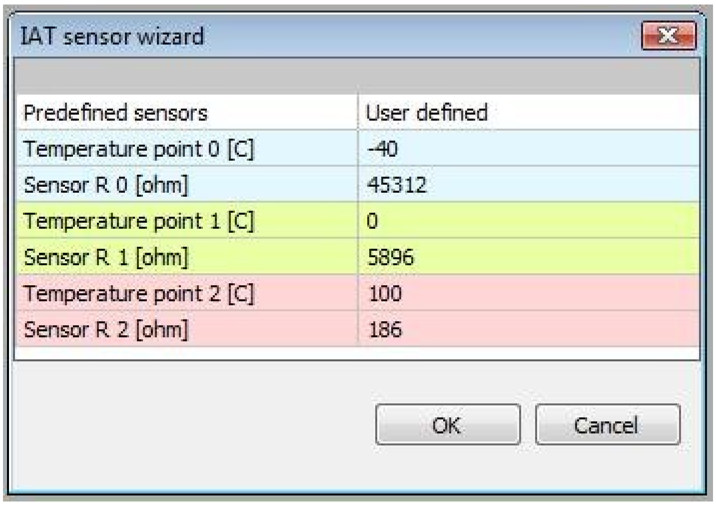
DESCRIPTION OF BASIC CONTROLS

The Client of EMU device consists of several basic controls, which task is to facilitate the proper configuration of the device. We can divide it into particular types:

	Wizard (creation)
	Paramblock (parameter's block)
	Table 2D
	Table 3D
	Visual log (parameters' log)
	Graph log (graphical log)
	Gauge

Wizard

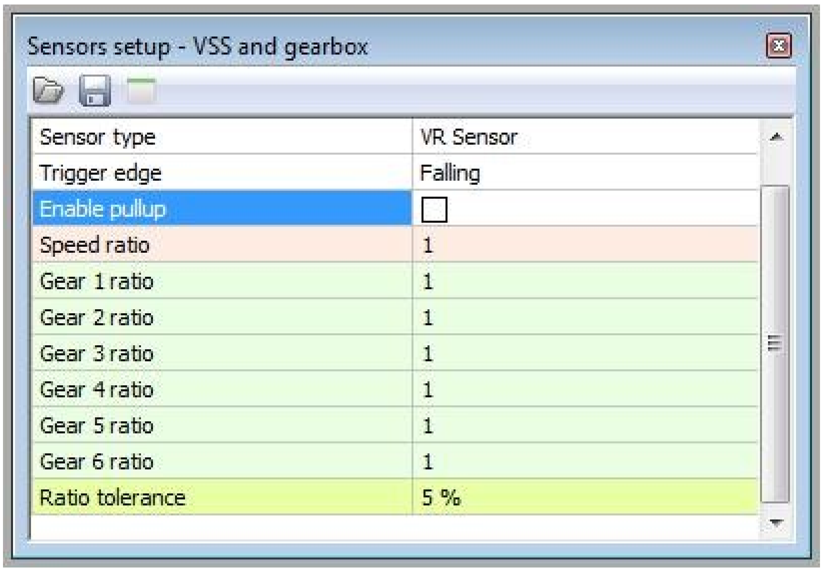
This tool allows you a quick selection of the saved, pre-specified, configuration of the given sensor. An example of a wizard for a intake air temperature sensor is as follows:



The first cell in the right column is always in the form of a drop-down list. It allows to select the right characteristics from the sensors or other devices defined by the manufacturer, such as: thermistors, NTC, injectors, or – by the option "**User defined**" – open a blank column to fill in the values for other sensors not defined in the program. Options of specific wizards will be discussed in appropriate sections of the manual.

Paramblock (parameters’ block**)**

It is a table, in which there are included particular options connected with the configuration of EMU functions. Because of this, it is possible to set all parameters required for the configuration of the given function.



Paramblock always has two columns, while the number of lines may vary from the example indicated above, depending on the configured device function.
In cells of the left column there are descriptions of particular options, while in the right column there are its values.
After clicking on the cell in the right column we get a chance to modify its content – this can either be a selection from the list, "on-off" option or simply a place to enter the value.

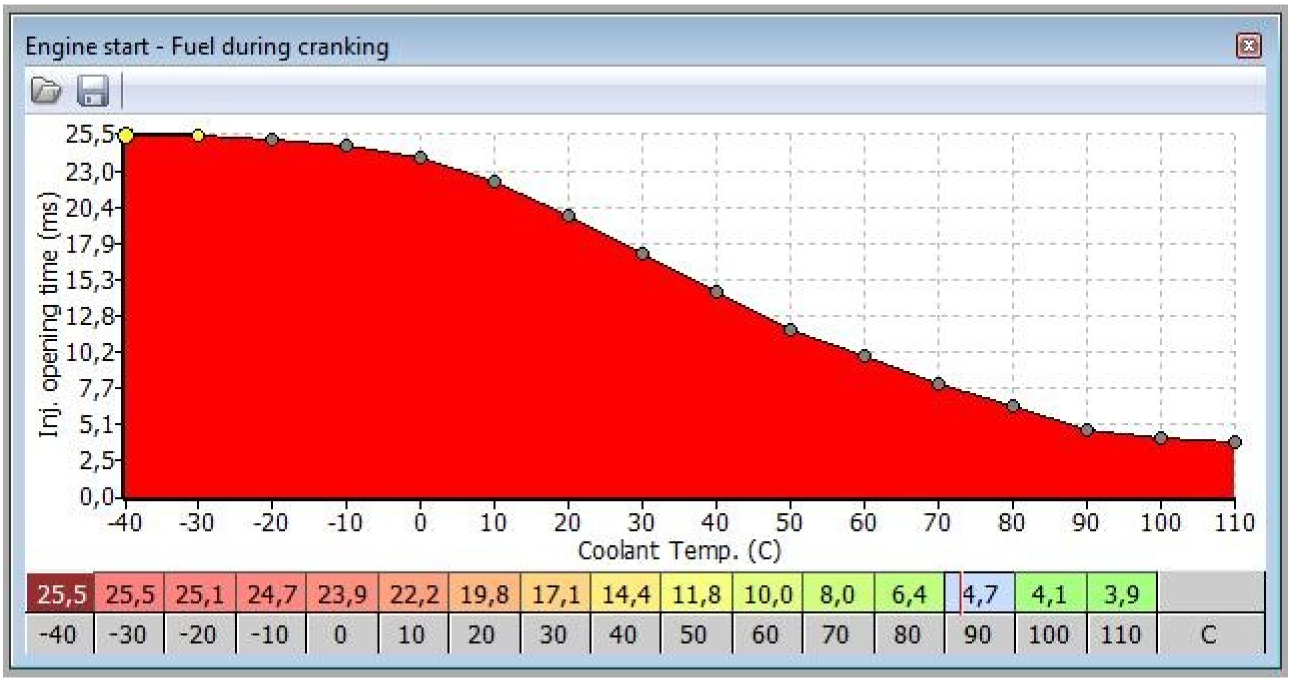
On the toolbar of this window there are 3 icons described below:

	Open the file with the configuration of the given parameters’ block
	Save the file with the configuration of the given parameters’ block
	Restore default values of the given parameters’ bloc

Saving particular parameters’ blocks is useful during the exchange of configuration with other users or to create the base of settings (e.g., configuration of various ignition systems).

Table 2D

2D tables have the form of two-dimensional graphs, and are used to describe two-dimensional non-linear functions. Thanks to their graphical form, they are clear and easy to use.



The table in the bottom are values presented in the graph. You can change the content of all cells, while the values from the upper line correspond to the vertical axis on the graph, and values in the lower axis to the horizontal one (*bins*).

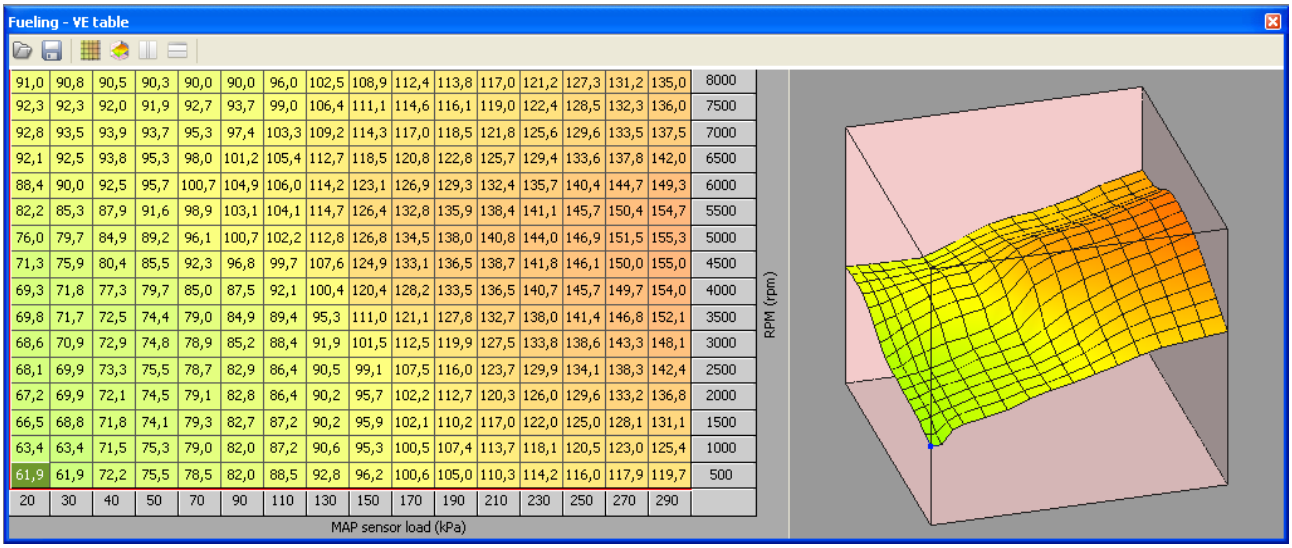
In order to change the content you should mark the cells, which you want to modify, and then enter the desired value. You can also change the value of cells by using the + and - keys. We will obtain a smaller change if we press the ALT key, and greater if we press SHIFT.

On the toolbar of this window there are 2 icons described below:

	Open the file with a 2D map
	Save the file with a 3D map

Table 3D

Below is an example of the three-dimensional map.



91,0	90,8	90,5	90,3	90,0	90,0	96,0	102,5	108,9	112,4	113,8	117,0	121,2	127,3	131,2	135,0	8000
92,3	92,3	92,0	91,9	92,7	93,7	99,0	106,4	111,1	114,6	116,1	119,0	122,4	128,5	132,3	136,0	7500
92,8	93,5	93,9	93,7	95,3	97,4	103,3	109,2	114,3	117,0	118,5	121,8	125,6	129,6	133,5	137,5	7000
92,1	92,5	93,8	95,3	98,0	101,2	105,4	112,7	118,5	120,8	122,8	125,7	129,4	133,6	137,8	142,0	6500
88,4	90,0	92,5	95,7	100,7	104,9	106,0	114,2	123,1	126,9	129,3	132,4	135,7	140,4	144,7	149,3	6000
82,2	85,3	87,9	91,6	98,9	103,1	104,1	114,7	126,4	132,8	135,9	138,4	141,1	145,7	150,4	154,7	5500
76,0	79,7	84,9	89,2	96,1	100,7	102,2	112,8	126,8	134,5	138,0	140,8	144,0	146,9	151,5	155,3	5000
71,3	75,9	80,4	85,5	92,3	96,8	99,7	107,6	124,9	133,1	136,5	138,7	141,8	146,1	150,0	155,0	4500
69,3	71,8	77,3	79,7	85,0	87,5	92,1	100,4	120,4	128,2	133,5	136,5	140,7	145,7	149,7	154,0	4000
69,8	71,7	72,5	74,4	79,0	84,9	89,4	95,3	111,0	121,1	127,8	132,7	138,0	141,4	146,8	152,1	3500
68,6	70,9	72,9	74,8	78,9	85,2	88,4	91,9	101,5	112,5	119,9	127,5	133,8	138,6	143,3	148,1	3000
68,1	69,9	73,3	75,5	78,7	82,9	86,4	90,5	99,1	107,5	116,0	123,7	129,9	134,1	138,3	142,4	2500
67,2	69,9	72,1	74,5	79,1	82,8	86,4	90,2	95,7	102,2	112,7	120,3	126,0	129,6	133,2	136,8	2000
66,5	68,8	71,8	74,1	79,3	82,7	87,2	90,2	95,9	102,1	110,2	117,0	122,0	125,0	128,1	131,1	1500
63,4	63,4	71,5	75,3	79,0	82,0	87,2	90,6	95,3	100,5	107,4	113,7	118,1	120,5	123,0	125,4	1000
61,9	61,9	72,2	75,5	78,5	82,0	88,5	92,8	96,2	100,6	105,0	110,3	114,2	116,0	117,9	119,7	500
20	30	40	50	70	90	110	130	150	170	190	210	230	250	270	290	

It consists of two main parts:

- Table with numeric values,
- Three-dimensional graph.

The way of modifying 3D maps is identical like in the case of 2D maps.

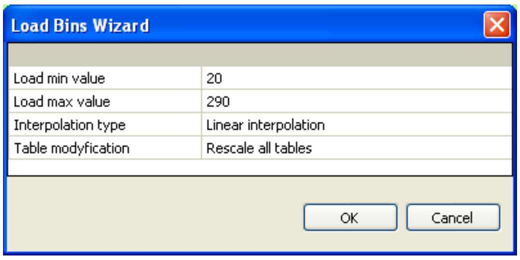
Additionally, on the toolbar there are the following icons:

	Open the file with a 3D map
	Save the file with a 3D map
	Display only numeric values
	Display only the 3D graph
	3D graph and map of values are horizontally divided
	3D graph and map of values are vertically divided

Additionally, on each 3D map you can modify values on the load axis (axis X), and values of rotations (axis Y). To do this you should start the right wizard (they are available by right clicking on the selected axis), or you can manually modify particular cells.

X axis bins wizard

This wizard is used for automatic generation of values for the load axis (X).



Load min value – minimal value for axis X,

Load max value – maximal value for axis X,

Interpolation type – way of dividing values on axis X between the minimal and maximal value. We have 3 options to choose from:

Linear interpolation **–** linear interpolation between values,

Exponential interpolation 1 – exponential interpolation, version 1,

Exponential interpolation 2 – exponential interpolation, version 2.

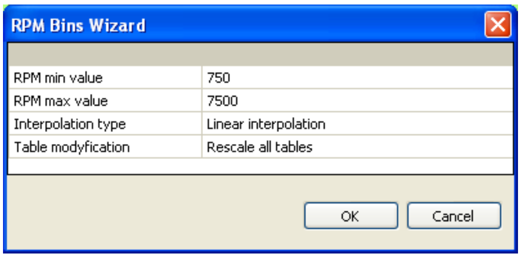
Table modification – defines the way of table's value processing in relation to the scale change of axis X.

Do not modify table – do not modify the table's value,

Rescale this table – modify only this table,

Rescale all tables – modify all tables using this definition of axis X (recommended)

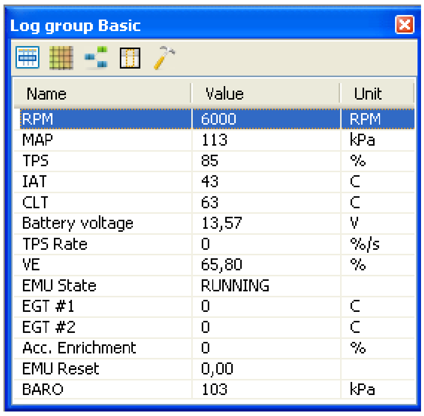
RPM bins wizard



Wizard of RPM values for scale Y acts identically as wizard for axis X.

Visual log

Using the parameters' log we can real-time track the selected parameters of the engine's work. Parameters are grouped according to the function, what facilitates tracking of the device's functions (e.g. *Idle control*)


Log group Basic

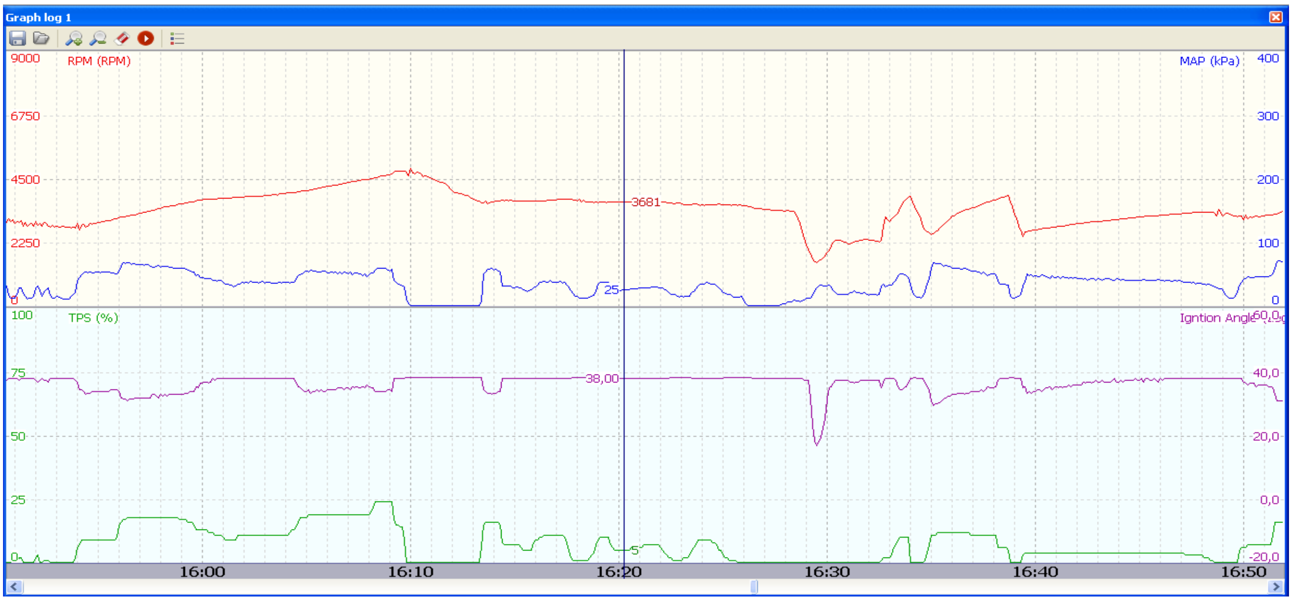
Name	Value	Unit
RPM	6000	RPM
MAP	113	kPa
TPS	85	%
IAT	43	C
CLT	63	C
Battery voltage	13,57	V
TPS Rate	0	%/s
VE	65,80	%
EMU State	RUNNING	
EGT #1	0	C
EGT #2	0	C
Acc. Enrichment	0	%
EMU Reset	0,00	
BARO	103	kPa

Gauges

It is an informative tool, used to control particular parameters' values in the real time. Apart from the analogue display with a needle on the scale at the 270 degree angle, the indicator also shows the precise value in the digital form. Examples are presented in the picture below:

Graph log

Graph log is a control used to observe and analyse selected parameters of the engine's work. The presented data are in the graph form, while the precise reading of these data can be obtained by moving the cursor on the selected point of the graph. The description of all logged parameters in is appendix 1 at the end of the manual.



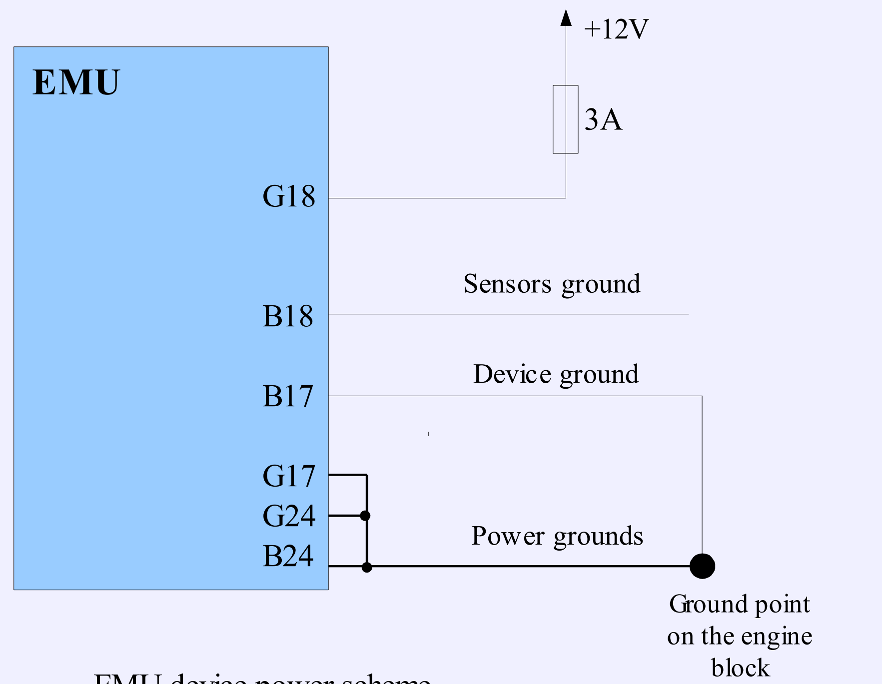
On the toolbar of this window there are 7 icons described below.

	Open the file with a 2D table
	Save the file with a 2D table
	Expand the logo's area
	Decrease the logo's area
	Clean the graph
 / 	Pause / resume displaying data. Registration of data in the memory takes place independently of this parameter.
	Add / subtract the displayed parameters from the list

CONNECTING THE EMU DEVICE

When connecting the EMU device, special attention should be paid to the connection of device's grounds and their wiring in the car's installation. Wrong connections can create loops, so called *Ground loops.* Bad ground connections can cause many problems, such as noisy readings from analogue sensors or problems with trigger errors. EMU device has several kinds of grounds. Device's grounds (pin B17) is a ground used to power the device, *analogue ground* (pin B18) is the ground point for analogue sensors, and *power grounds* (B24, G17 i G24) are used to supply power outputs and ignition outputs. The perfect situation is when the device's ground and *power ground* are connected to one ground point on the block / engine's head and are lead through separate wires. Power grounds in case of using active coils should be connected using wires with the 1,5 – 2mm diameter. +12V power supply should be connected through the 3A fuse.

Below are the examples of grounds' connections to the device.



EMU device power scheme

SENSORS

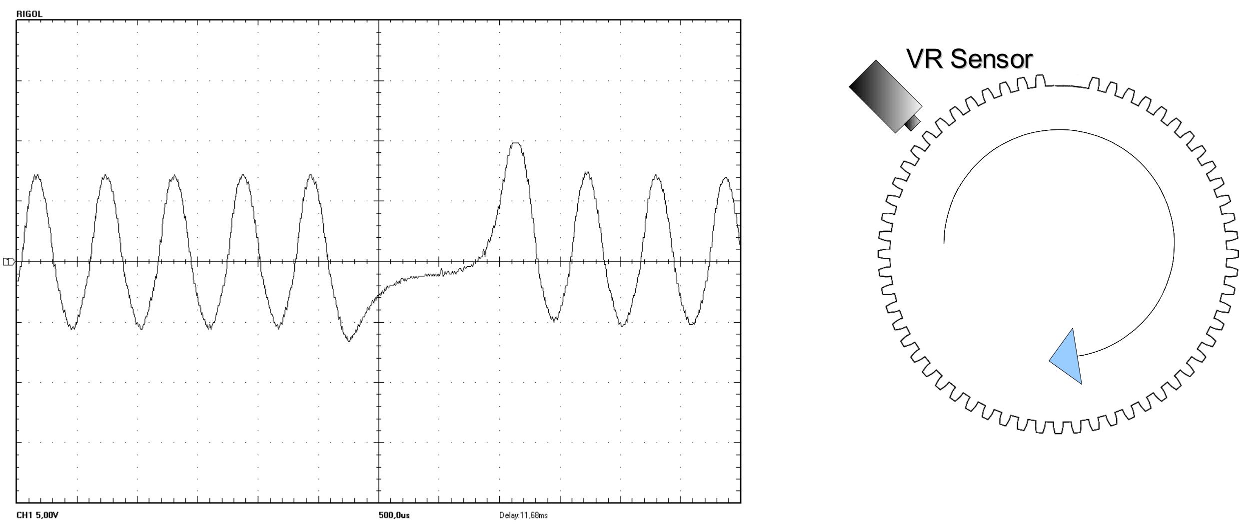
In case of sensors used in cars' electric installations, we are dealing with several types:

- resistance sensors,
- voltage sensors,
- magneto-inductive sensors,
- optical sensors / Hall's,

Resistance sensors are used to measure temperatures (e.g. temperature of cooling liquid) or the position of a throttle (TPS sensors). Voltage sensors are characterised by the fact that the value they measure is expressed in voltage. Such sensors include the sensor of absolute pressure in the intake manifold or the knock sensor.

The key sensors, from the point of view of engine's management work, are sensors of crankshaft's positions and/or of camshaft, thanks to which it is possible to read the speed of the engine and to control the ignition angle and injection.

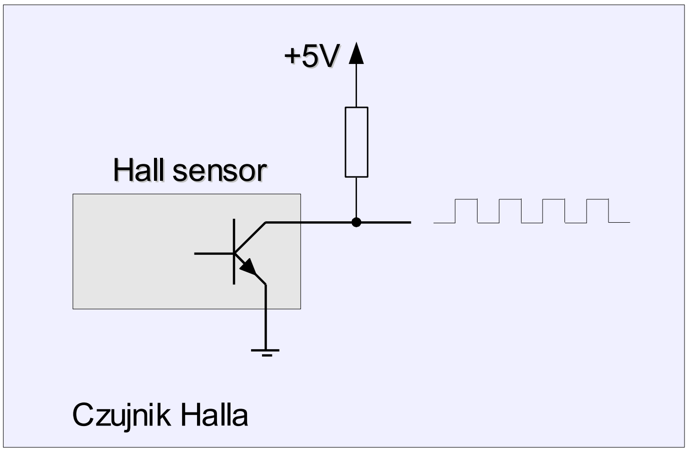
The most popular sensor of this type is the variable reluctant (VR) sensor. It works on the principle of inducing the electromotive force in the winding of sensor's coil wound on a permanent magnet, under the influence of ferromagnetic movement of the impulse wheel. The induced voltage is proportional to the sensor's distance from the impulse wheel and its rotational speed.

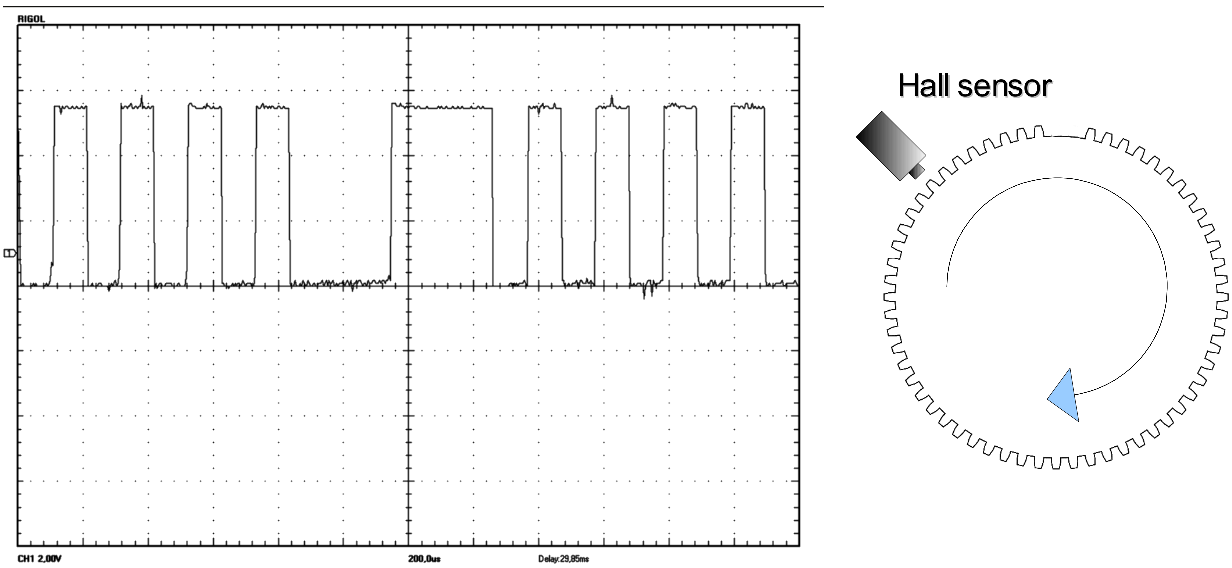


Scope trace of VR sensor output using trigger wheel 60-2

What is characteristic for this sensor is the fact that it has polarity, what is crucial when connecting it to EMU. Inversely connected will prevent the synchronization of ignition. Signal from such sensor, especially with low speeds, where its amplitude reaches several hundred millivolts, is very sensitive to interference. For that reason it must always be connected with the cable in the screen. It should also be emphasized that the screen connected to the mass can be only on one side of the cable.

A different kind of sensor of engine speed is a sensor using the so-called Hall's phenomenon. In contrast to the variable reluctant sensor, it requires powering. In most such cases, sensors have "open collector" outputs and require using the *pullup* resistor (in case of EMU computer, *pullup* 4K7 resistor is activated with the proper output configuration.

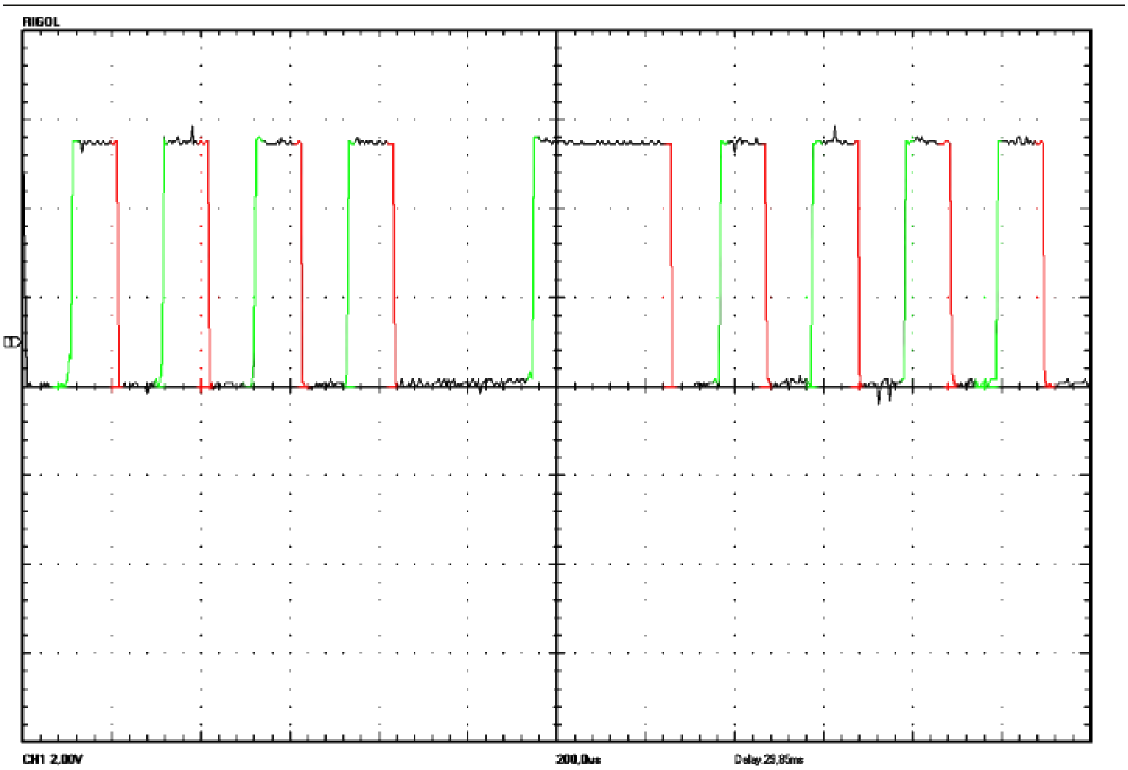




Scope trace of Hall sensor output using trigger wheel 60-2

Hall's sensors require powering (5-12V), but they are much more resistant to interference than magneto-inductive sensors. In practice, we also use shielded cables to minimise chances of interference of the signal from the sensor.

In case of signals waveform from Hall sensors, we are also dealing with the term of so-called signal edge (*signal edge*). We can distinguish two edges: rising (*rising,* when the voltage's value grows) and falling (*falling*, when the voltage's value falls).

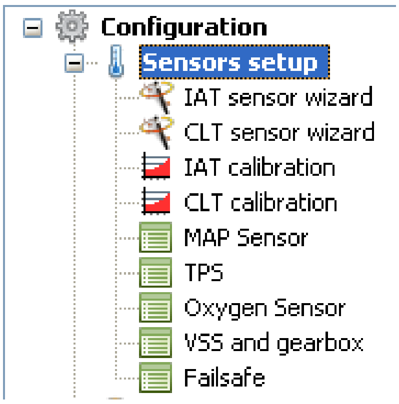


In the picture above the falling edges *are marked* with red colour, and the rising edges with green colour.

SENSORS CALIBRATION

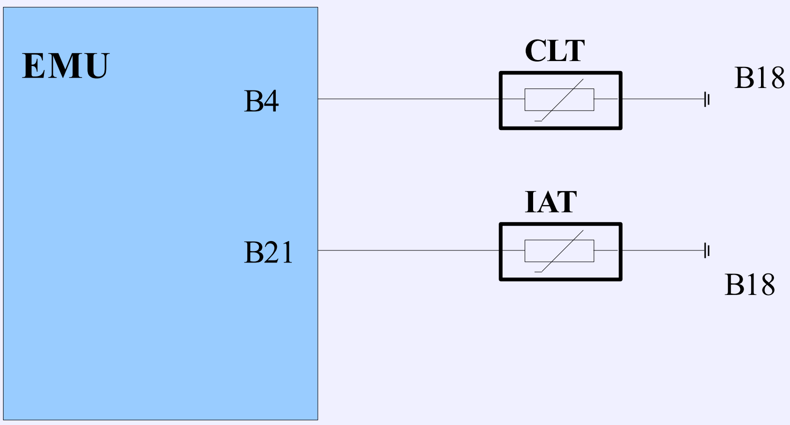
Calibration of analogue sensors is done from the *Sensors Setup* level.

Coolant temperature sensor (CLT) and intake air temperature (IAT)



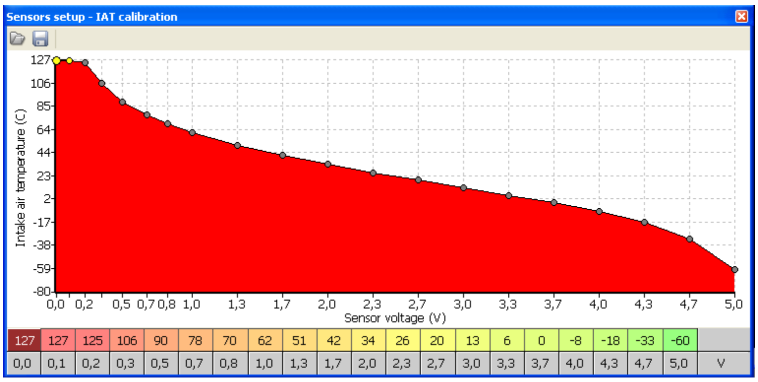
AT and CLT sensors are in most cases the NTC thermistors. NTC thermistor is a nonlinear resistor, which resistance depends strongly on temperature of the resistance material. As the English names indicates - *Negative Temperature Coefficient* – thermistor has a negative temperature coefficient, so its resistance decreases when temperature grows.

These sensors are connected to the EMU device in the following way:

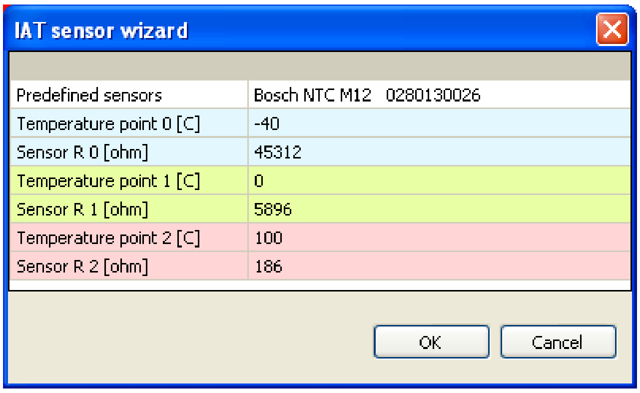


CLT and IAT sensors wiring diagram

IAT and CLT sensor calibration takes place by using 2D tables, respectively, *IAT Calibration* and *CLT Calibration.* This table defines the divider's voltage created by the sensor and built in the EMU pull-up resistor corresponding to the given temperature. In order to facilitate the sensor calibration, you should use the wizard.



Using the wizard we can use the predefined sensor, or create its characteristic, providing the sensor resistance for 3 known temperatures. The highest difference of temperatures is recommended in the wizard (these data can be found in the car's service book or can be collected with ohmmeter in 3 different temperatures)



Predefined sensors – names of predefined sensors. In case of choosing the „User defined" sensor it is possible to add temperature values and resistance of own sensor.
After selecting the sensor, you should press the OK button, what will create the calibration table.

Uwaga !

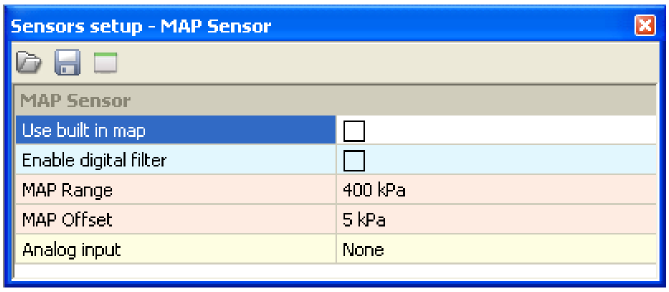
To permanently save a change in the device's FLASH memory, you should select *Make Maps Permanent* option (shortcut key F2).

MAP SENSOR (*manifold absolute pressure sensor*)

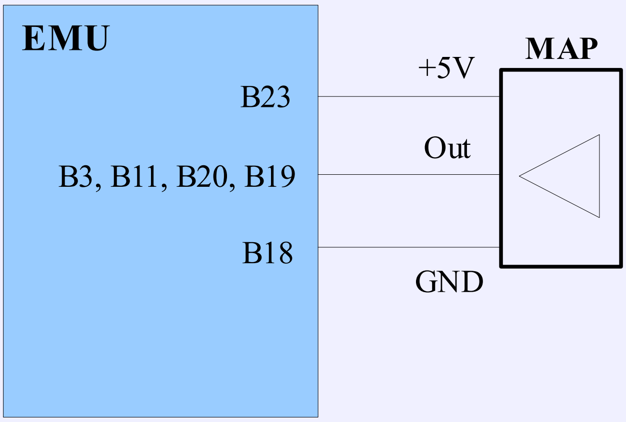
Pressure sensors are used to measure pressure in the engine's intake manifold (MAP sensor) and atmospheric pressure (baro sensor). MAP sensor fulfils the following functions:

1. In algorithm *Speed Density* determines the engine's load and is the basic parameter while calculating the fuel's dose and the angle of ignition's timing.
2. In case of boost control in the feedback loop, the pressure's value in the intake collector is the basic information for the algorithm.
3. Fuel cut, when the pressure value is very low or exceeds the maximum value (overboost fuel cut).
4. BARO sensor is used to calibrate the fuel dose in case of algorithm Alpha-N

MAP sensor pressure should be taken from the intake manifold from the place closest to the throttle, so that its value most closely matches the average pressure value in the intake manifold. Pressure hoses should be as short as possible, with hard walls. In case of individual throttle bodies, pressure from each runner should be connected to the collecting can and only then to the MAP sensor. EMU device has an in-built pressure sensor with the measuring range of 400kPa, and the in-built barometric pressure sensor. It is possible to use the external MAP sensor connected to one of the analogue inputs.



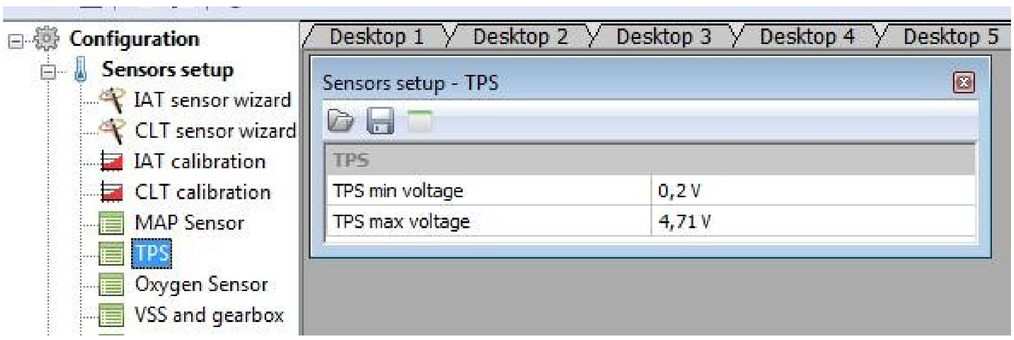
Using the configuration of the MAP sensor we can decide whether use the in-built sensor (*Use built in map*) or the external one. In case of using the external sensor we should choose the analogue input, to which we connect (*Analogue input*) and we enter its measuring scope 0 (*MAP range and MAP offset*).



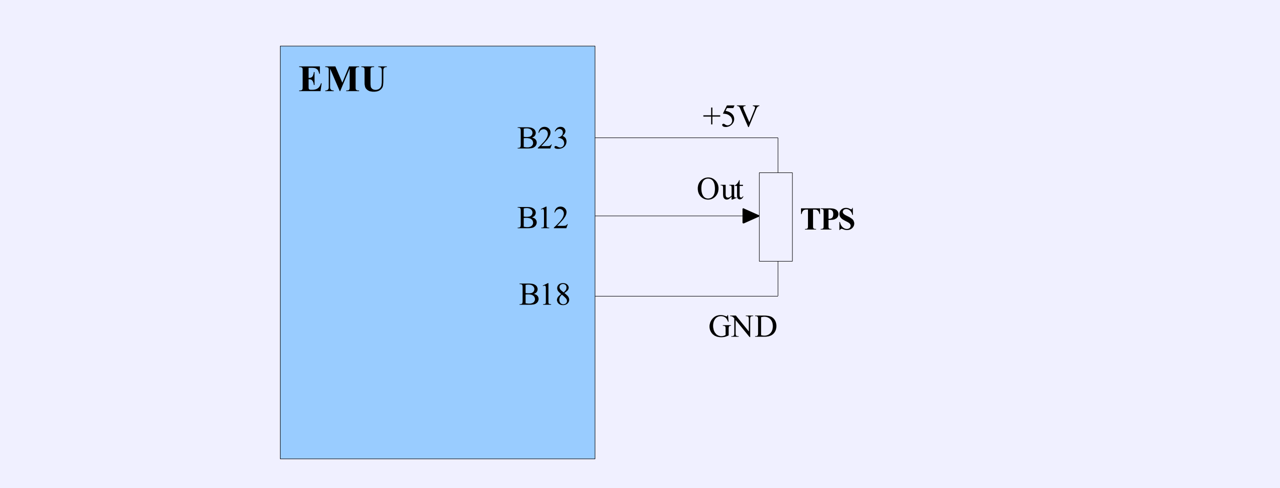
Schemat podłączenia zewnętrznego czujnika MAP

TPS *(Throttle position sensor)*

Throttle position sensor is, next to MAP sensor, the key sensor allowing to define the engine's load in algorithm Alpha-N, to calculate the coefficient of enriching the mixture with the acceleration and controlling engine idle. Calibration of this sensor is limited to the determination of 2 limit positions of the boundary locations of acceleration pedal. Below is the configuration of this sensor:

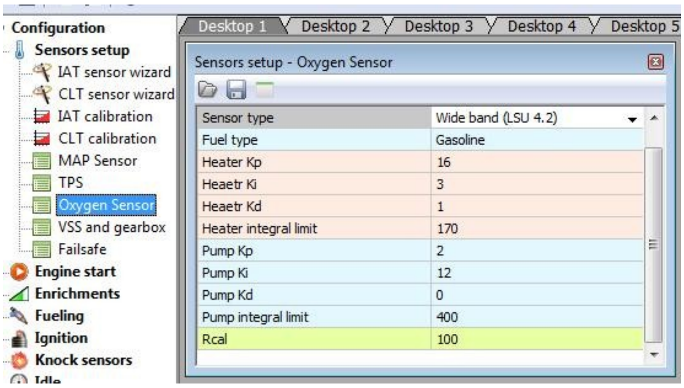


TPS sensor should be connected as follows:



TPS sensor wiring diagram

Lambda sensor



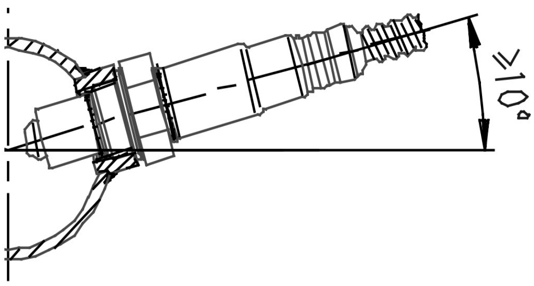
Lambda sensor allows to determine the composition of fuel-air mixture. EMU device supports both the narrowband sensor and the wideband sensor (Bosch LSU 4.2) The selection of the sensor is done in the set of parameters *Oxygen Sensor (Sensor Type).* In case of narrowband sensor, the further configuration is not required. In case of LSU 4.2 probe you should choose the fuel type (ARF value depends on it), and set the *Rcal* value (this is the value of sensor's calibration resistor and it can be measured with ohmmeter (ranges from 30-300 ohms) between pins of 2 and 6 of LSU 4.2 sensor connector)

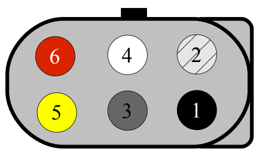
Uwaga !
Incorrect Rcal value will cause false readings of the lambda sensor!

Values connected with PID controllers of lambda sensor controller should not be modified.

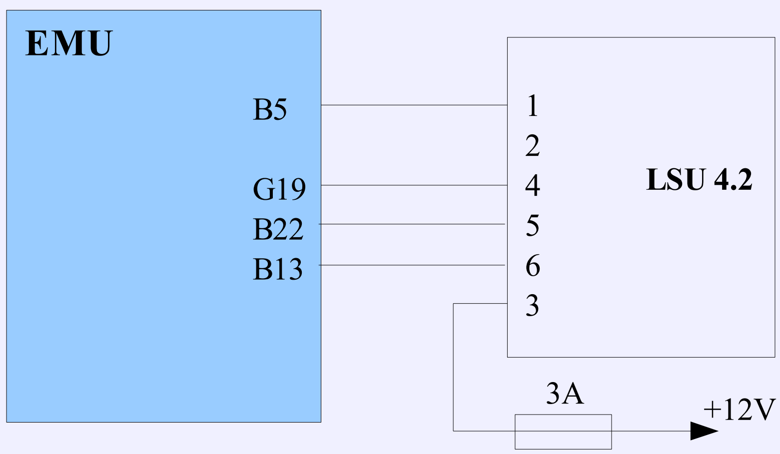
In case of LSU 4.2 probe, you should apply the following guidelines:

- the probe must be installed in the place, where temperature of exhaust gas does not exceed 750 degrees,
- in turbo cars we install oxygen sensor in downpipe,
- the sensor should be installed in the position close to vertical,
- you should always use original connectors,
- the connectors must be clean and dry. You must not use means like contact spray or other anti-corrosion means,
- you must not drive without a connected sensor into the EMU device, as it will cause a significant shortening of probe's life,
- EMU requires calibration (*Rcal* parameter) when being connected to the new probe.





Installation of the lambda probe in the exhaust system. **Pionout of the LSU 4.2 connector**



Bosch LSU 4.2 wiring diagram

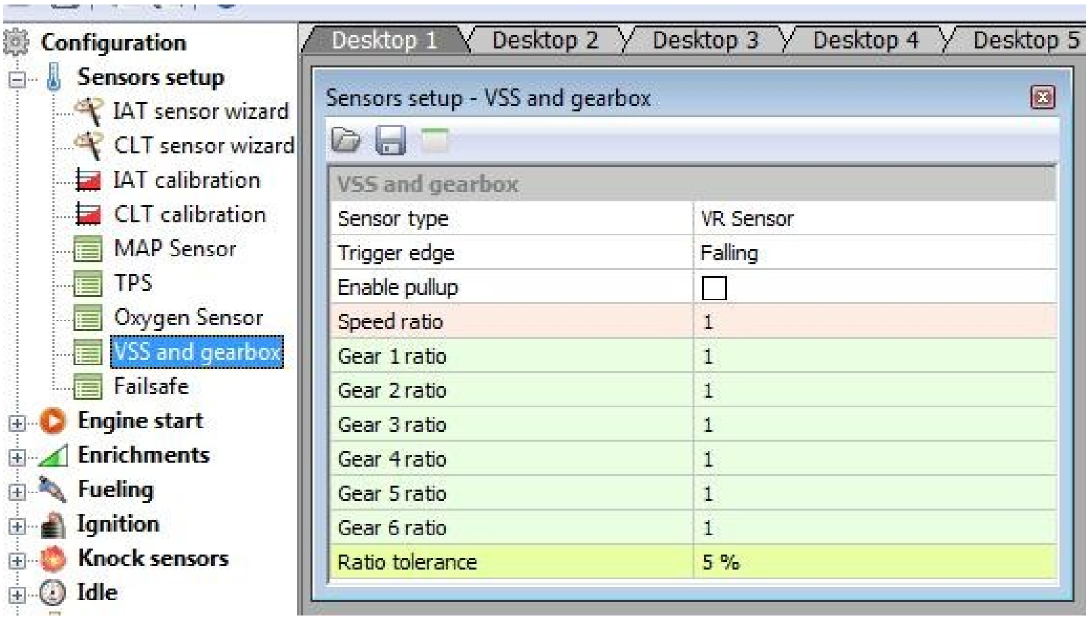
VSS AND GEARBOX

Vehicle's speed sensor is usually placed in the gearbox. It is used by factory systems, e.g., speedometer or the system supporting the steering wheel (e.g., electrical support system). Vehicle's speed can be also read from ABS sensors.

Ecumaster EMU device uses the VSS reading to regulate the boost pressure towards the vehicle's speed, controlling idle or the recognition of the currently selected gear.

To configure the VSS sensor, you should open the set of parameters VSS and gearbox.

Types of sensors and signals, which they generate, have been described in the following sections.



Sensor type – type of sensor used to read the speed. We can choose Hall's sensor or inductive sensor (*VR sensor*),

Trigger edge – selection of the signal's edge, which is to be used to read the speed,

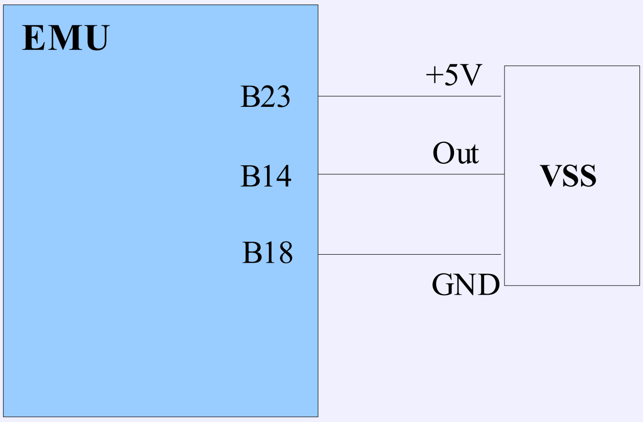
Enable pullup – switching the internal pull-up resistor (4K7), used in case of Hall's sensor,

Speed ratio – value of the multiplier of signal's frequency from VSS sensor giving the right speed expressed in km/h,

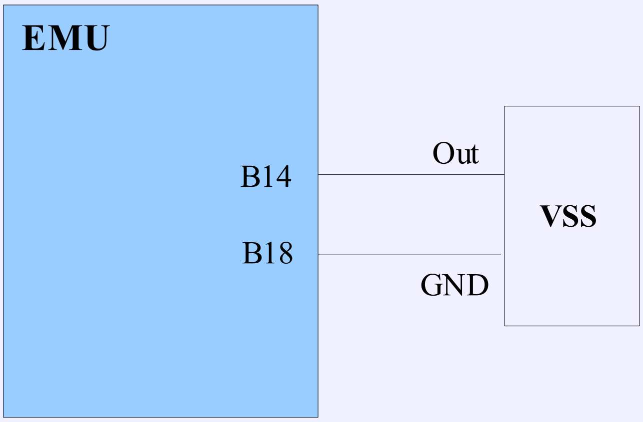
Gear 1- 6 ratios – relation of frequencies from VSS sensor to the engine's RPM. Information about the current value can be read from the log (channel *Gear ratio*),

Ratio tolerance – percentage value of the error while determining the current gear.

VSS sensor's connection



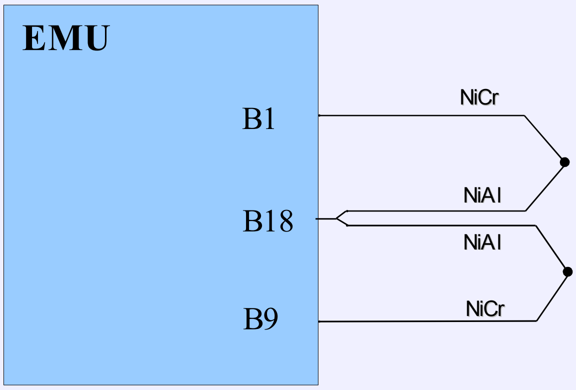
VSS wiring diagram. Hall type sensor



VSS wiring diagram. VR type sensor

EXHAUST TEMPERATURE SENSOR

EMU device can use the K type thermocouple to measure the exhaust temperature. Sensor should be installed as close to head's exhaust channels as possible.



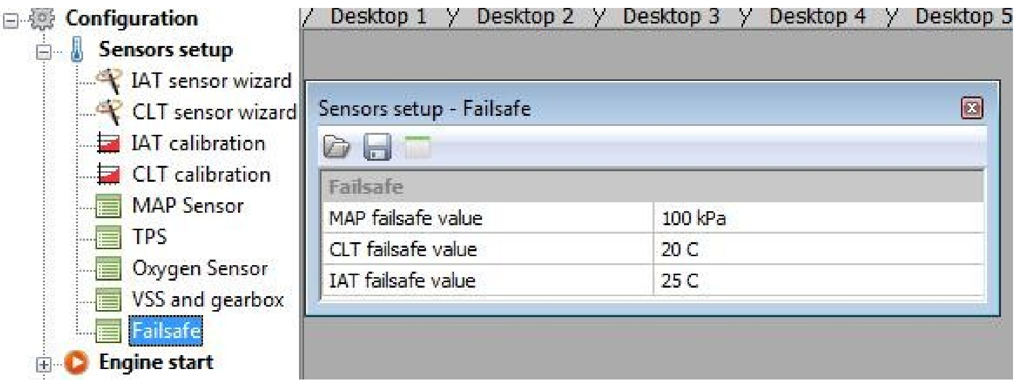
K type thermocouples connection diagram

Attention!	
⚠	To maintain the accuracy of a thermocouple measurement system, K type thermocouple cable is required to extend from the thermocouple sensor to the EMU device.

FAILSAFE

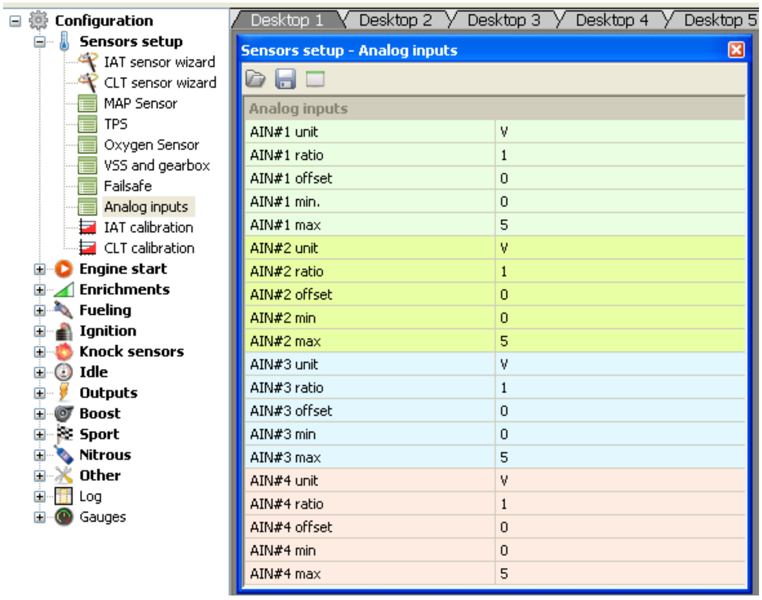
In case of failure of essential engine's sensors, EMU device is equipped with a protection, enabling the further ride under certain conditions. Smooth operation of the engine and its power will be significantly lost, however this allows to keep the vehicle's mobility, which allows you to reach the service point.

In case of failure of any sensors IAT, CLT or MAP, EMU device will automatically take on values determined by the user for the damaged sensor. These values can be adjusted in the parameter set Failsafe.



Analog Inputs

EMU device has 4 analogue inputs, which can be used as inputs activating functions of the device, such as, e.g., launch control, or to log in signals from additional sensors. There is a possibility to configure sensors, so that voltage from the sensor is presented as physical value, e.g., pressure expressed in bars. To configure sensors connected to analogue inputs you have to use parameters Analogue Inputs.



Unit - unit, in which values of the given analogue output will be represented,

Ratio - multiplicative constant of equation,

Offset - additive constant of equation,

Min. - minimal value of signal,

Max. - maximal value of signal.

Output value [UNIT] = Input voltage * RATIO + OFFSET

FUELING PARAMETERS

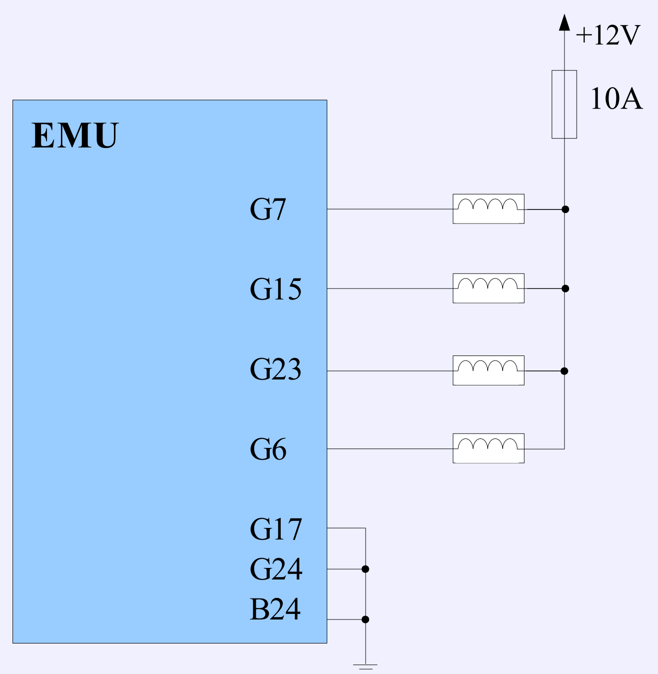
Configuration of *Fuelling* parameters is responsible for fuel dosing, both for the dose's size and the fuel injection angle. The performing element in case of fuel dosage is the injector. It is the electro valve that allows the precise dosage of the sprayed fuel. Fuel dosage is regulated by the width of electric impulse on the winding of injector coil.

Directly to EMU we can connect Hi-Z injectors (>= 8 Ohm). Up to 2 Hi-Z injectors can be connected to one *Injector* output . In case of Lo-Z injectors (<4 Ohm) we should apply the resistor limiting the current (4,7 Ohm 50W) for each injector or additional external *Peak and Hold* controller.

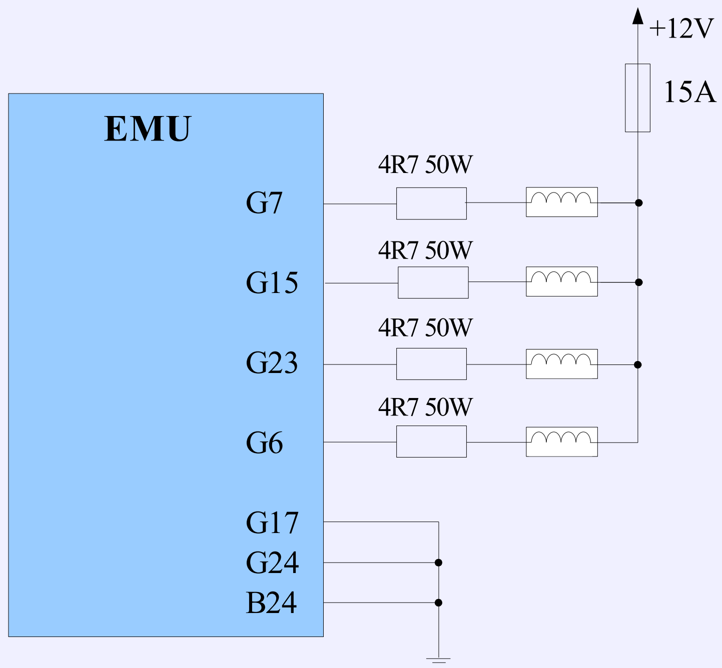
Attention !
Connecting Lo-Z injectors directly to EMU device can lead to the damage of the device or injectors.

Attention !
Injectors should be powered by the properly selected fuse. The fuse's value results from the maximal current taken by the given injectors.

Injectors are controlled by switching to the ground and require the connected power grounds (G17, G24, B24)



4 Hi-Z injectors wiring example



4 Lo-Z injectors wiring example

SELECTION OF INJECTORS

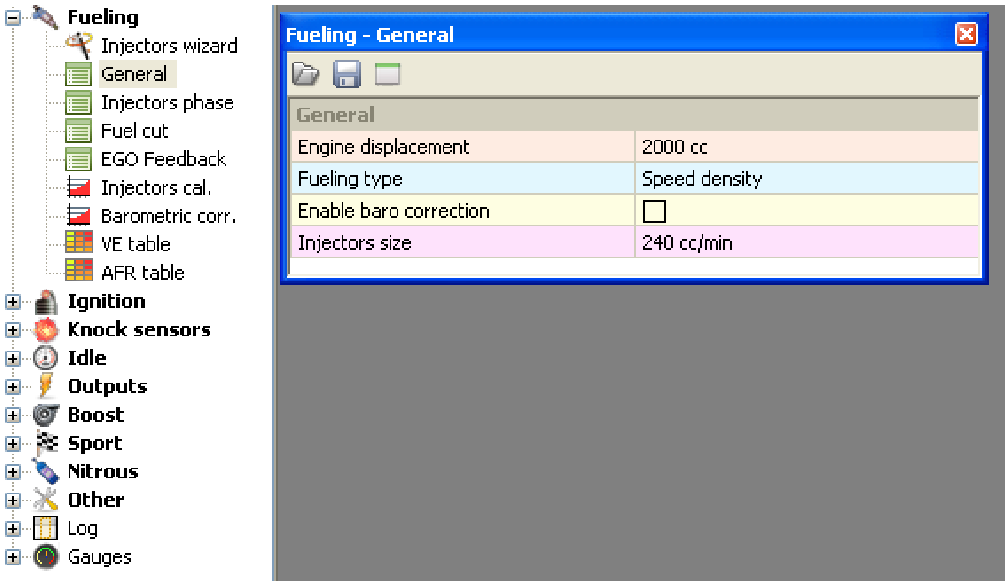
To determine required injector's flow rate, you should know the engine's BSFC. BSFC (*brake specific fuel consumption*) is the amount of fuel needed to generate 1 horsepower per hour. For naturally aspirated engines this value is about 5,25cm^3/min, while for turbo engines about 6cm^3/min. We select injectors' flow rate to achieve the expected power with 80% duty cycle (DC). Fuel injector duty cycle is a term used to describe the length of time each individual fuel injector remains open relative to the amount of time that it is closed and is expressed in %.

Injectors flow rate = (Horsepower * BSFC) / (number of injectors * max. DC)

For example, for 4 cylinder naturally agitated engine with 150KM power

Injectors flow Rate = (150 * 5,25) / (4 * 0,8) = 246 cm^3/min

GENERAL



Engine displacement – engine displacement in cm^3

Fueling type – selection of algorithm used for calculating fuel's dose. Description of algorithms has been presented on the next page.

Enable baro correction – activates real time correction of fuel's dose in the function of barometric pressure. The correction is defined in *Barometric correction table*. This function should be used in algorithm Alpha-N.

Injectors size - flow rate of the single injector in cm^3/min. It is assumed that the number of injectors is equal to the number of cylinders. If their number is different, you should give the average flow rate for a single cylinder.

SPEED DENSITY

The basic algorithm of calculating the fuel dose can be used for turbo engines as well as for naturally aspirated ones. It can be characterized by the fact that engine's load is defined by the value of absolute pressure in the intake manifold.

In this algorithm the fuel dose is calculated as follows:

PW = INJ_CONST * VE(map,rpm) * MAP * AirDensity * Corrections + AccEnrich + InjOpeningTime

PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(map, rpm)	value of volumetric effectiveness read from the VE table
MAP(*manifold absolute pressure*)	Intake manifold pressure
AirDensity	percentage difference of air density towards air density in temperature 21°C
Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

ALPHA-N

Algorithm used in naturally aspirated engines, where there is no stable vacuum (sport cams, ITB, etc.). It is characterized by the fact that the load is defined by the TPS. It is not sutable for turbocharged engines.

PW = INJ_CONST * VE(tps,rpm) * AirDensity * Corrections + AccEnrich + InjOpeningTime

PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(tps, rpm)	value of volumetric effectiveness read from the VE table
AirDensity	percentage difference of air density towards air density in temperature 21°C
Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

ALPHA-N with MAP multiplication

Algorithm combining features of Speed Density and Alpha-N. The load is defined by TPS, while VE value is multiplied by the value of absolute pressure in the intake manifold. It can be used for both naturally aspirated and turbocharged engines.

PW = INJ_CONST * VE(tps,rpm) * MAP * AirDensity * Corrections + AccEnrich + InjOpeningTime

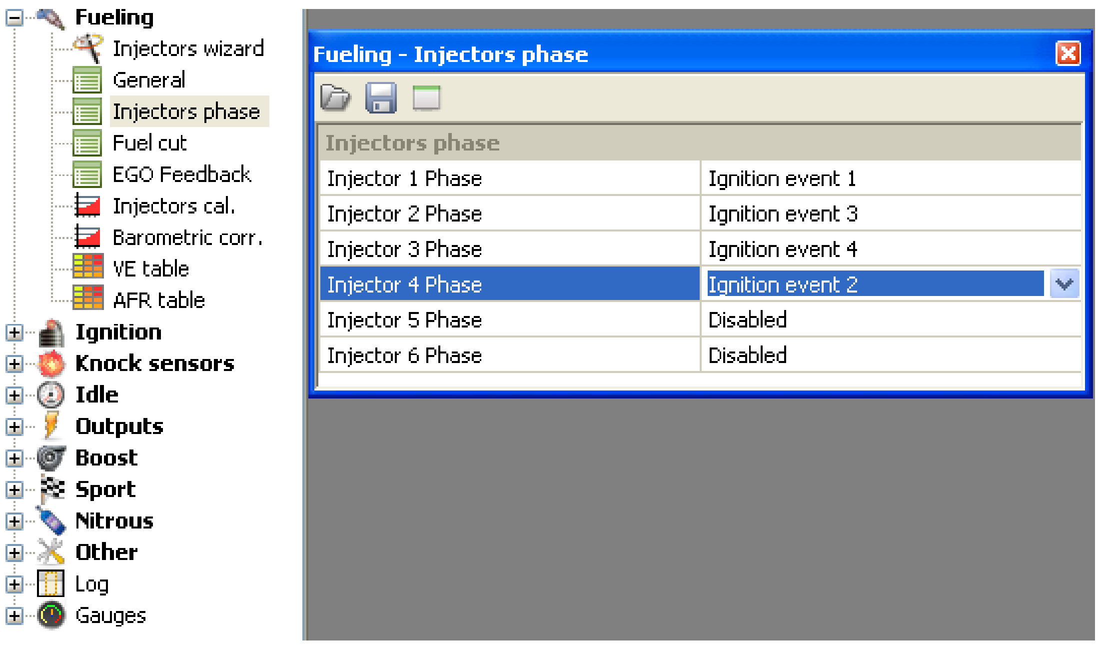
PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(tps, rpm)	value of volumetric effectiveness read from the VE table
MAP(*manifold absolute pressure*)	Intake manifold pressure
AirDensity	percentage difference of air density towards air density in temperature 21°C
Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

CORRECTIONS

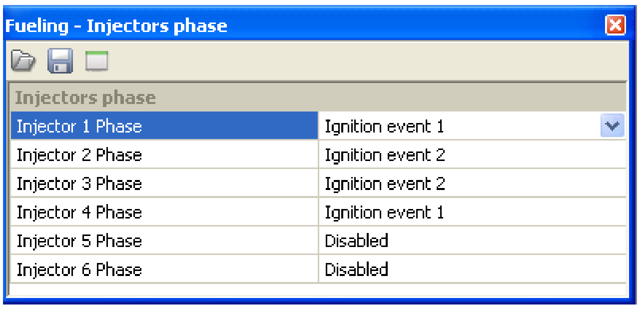
Corrections = Baro * Warmup * ASE * EGO * KS * NITROUS

Corrections	Final percentage value of fuel dose correction
Baro(*barometric correction***)**	Barometric correction used in Alpha-N algorithm
Warmup*(warmup enrichment)*	value of mixture enrichment in the function of cooling liquid temperature expressed in percentage
ASE(*Afterstart enrichment)*	Enrichment applied after engine start for given number of engine cycles
EGO(*Exhaust gas oxgen sensor correction***)**	correction according to indications of the Lambda probe
KS(*Knock Sensor Correction)*	enrichment in the moment of knock occurrence
NITROUS	enrichment of the mixture with the activation of nitrous oxide system

INJECTORS PHASE



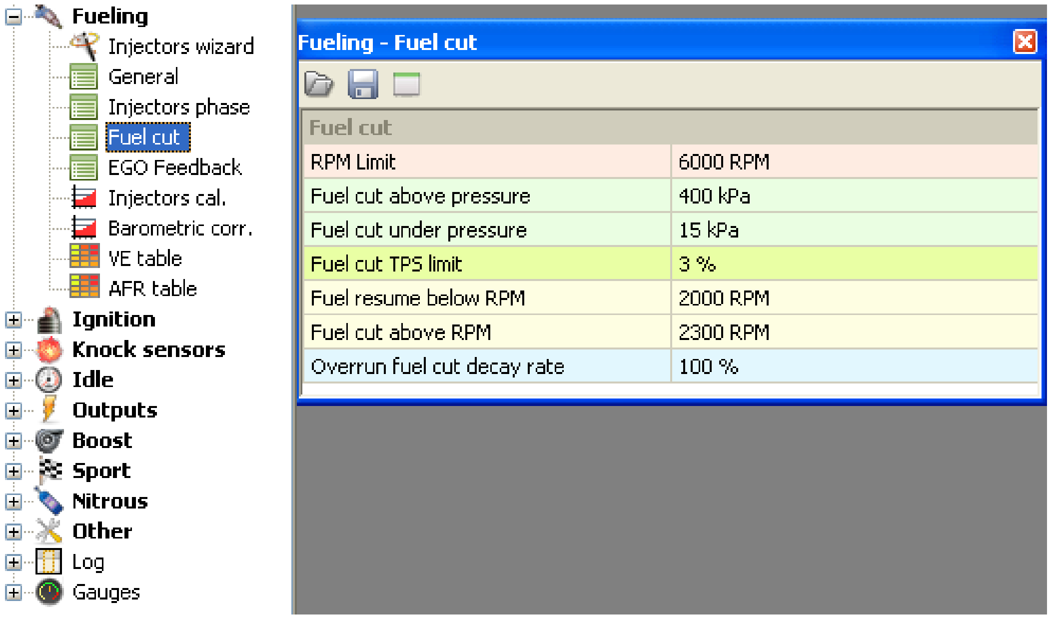
Injector Phase table combines the moment of fuel injection of specific ignition event. Ignition events in the engine's work cycle amounts to the number of cylinders. In the picture above there is presented the configuration of injectors in the full sequence for the ignition order 1-3-4-2. In case of the *wasted spark* injector, *Injector Phase* table may look as follows:



It should be emphasized that each injector is activated only once during the engine's work cycle (720 degrees).

FUEL CUT

Parameters *Fuel Cut* are responsible for cutting the fuel dose in case of exceeding the demanded RPM, pressure in the intake manifold or in case of closing the throttle plate.



RPM Limit – engine's speed, above which the fuel dose is completely cut.

Fuel cut above pressure – pressure in the intake manifold above which the fuel dose is completely cut. It is used as the protection from overboost.

Fuel cut under pressure – cutting the fuel dose in case the pressure drops below the defined level.

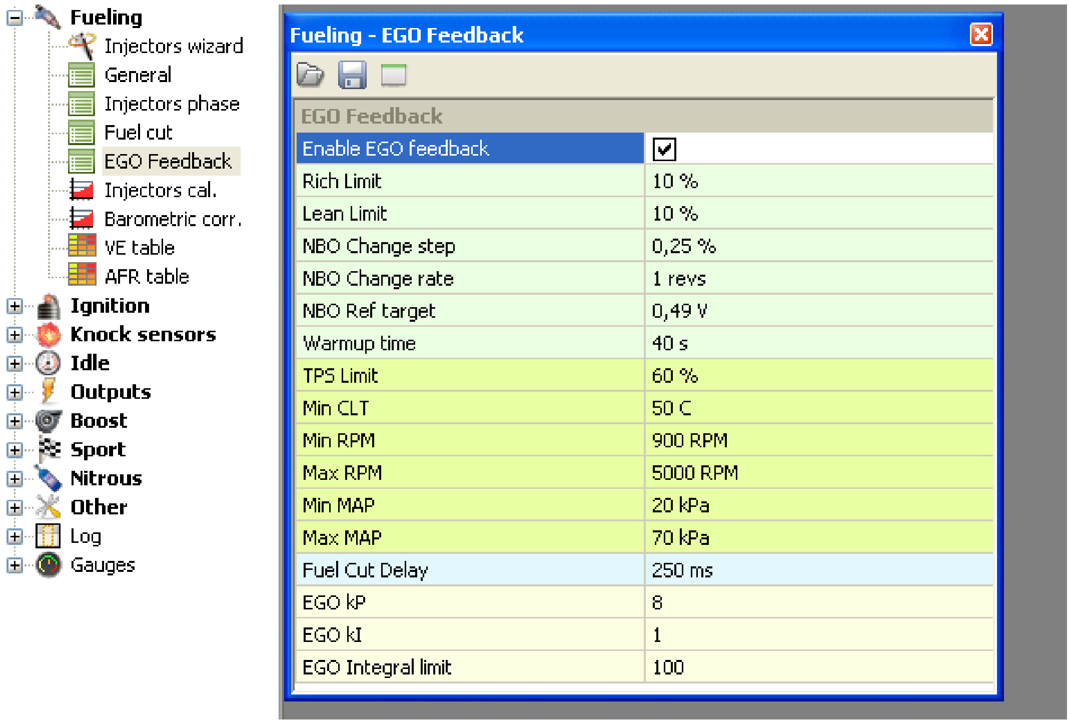
Fuel cut TPS limit – value from the TPS sensor below which the fuel dose can be cut, if engine speed is above *Fuel cut above RPM*,

Fuel cut above RPM – if the value of TPS sensor is below the value *Fuel cut TPS limit* and RPM are above this value, the fuel dose is cut.

Fuel resume below RPM – value of RPM below which the fuel dose is resumed,

Overrun fuel cut decay rate – in case the fuel dose is cut, it defines the percentage how the fuel dose should be decreased in the next engine turnover.

EGO FEEDBACK



EGO Feedback function is used to configure the work of algorithm of fuel dose correction using the feedback from the Lambda sensor (both narrow and wide band). In case of narrow band probe, we can only maintain value of *NBO Ref Target*. In case of wide band probe, AFR value for the desired RPM and engine load is defined in the AFR table.

Enable EGO feedback – activates the function of fuel dose correction,

Rich limit – percentage value of the maximal enrichment of the fuel dose,

Lean limit – percentage value of the maximal leaning the mixture,

NBO change step – value used only in case of narrow band probe, it determines the percentage the fuel dose can be changed,

NBO change rate - value used only in case of narrow band probe, it determines how often the change of fuel dose can be made,

NBO ref target – reference value of narrow board probe voltage,

Warmup time - value determining the minimal time from the moment of starting the engine, after which the correction of fuel dose is allowed,

TPS limit – value from the TPS below which the mixture correction is allowed,

Min CLT – minimal value of temperature of the cooling liquid above which the mixture correction is allowed,

Min RPM – minimal value of RPM above which the mixture correction is allowed,

Max RPM – value of RPM, above which the mixture correction is switched off,

Min MAP – minimal value of pressure in the intake manifold above which the mixture correction is allowed,

Max MAP – maximal value of pressure in the intake collector above which the dosage correction is disabled,

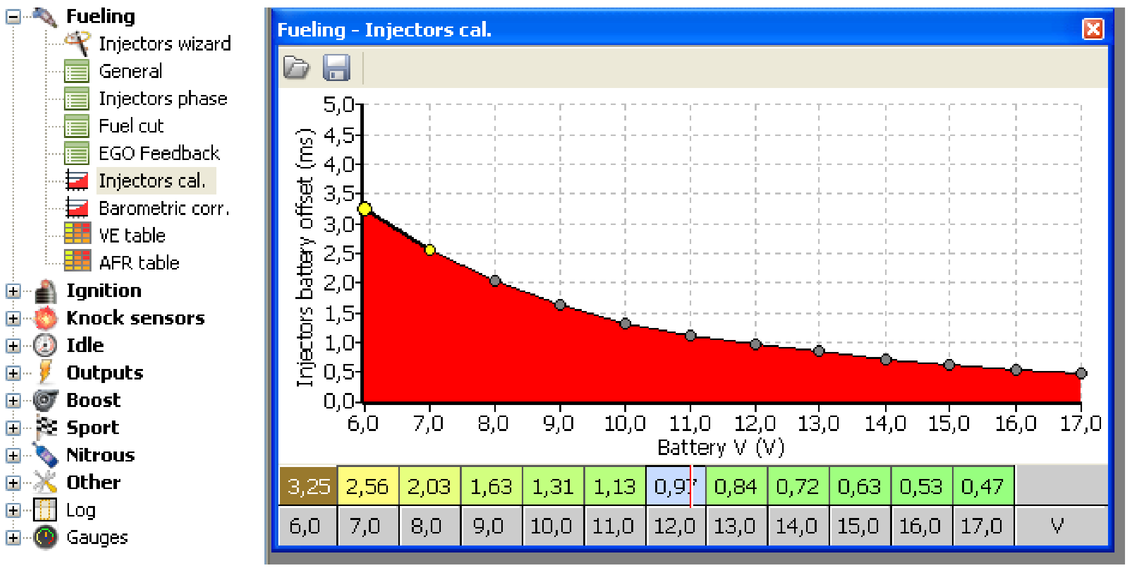
Fuel Cut delay – ime in ms after which the correction is resumed, after cutting the Fuel Cut,

EGO kP – gain coefficient of the proportional term of the PID algorithm,

EGO kI – gain coefficient of the integrator term of the PID algorithm,

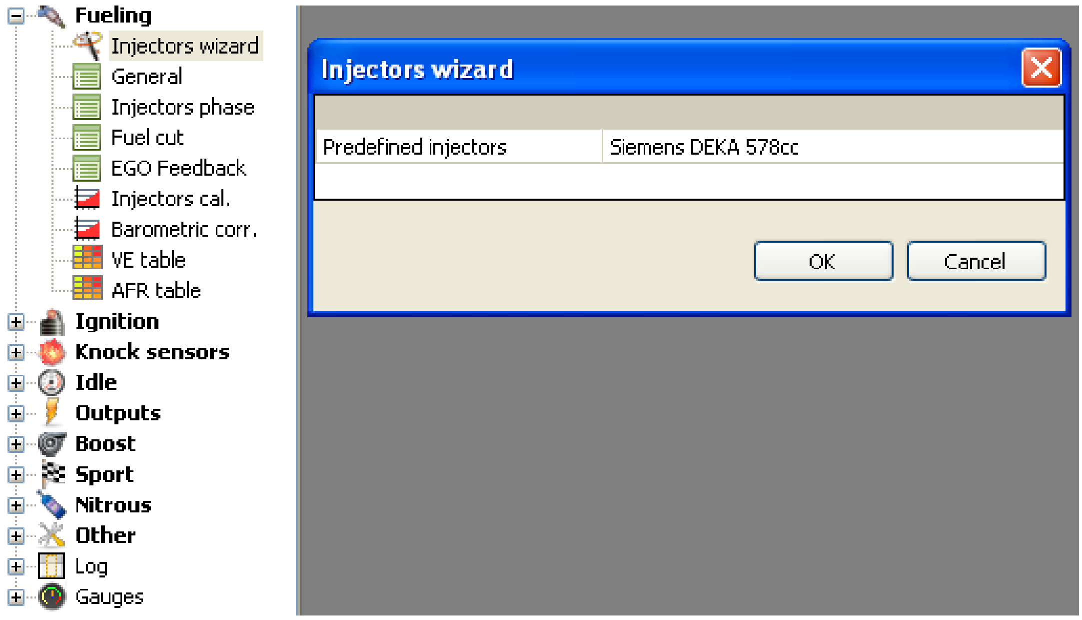
EGO Integral Limit – value of the limit of the integrator term of the PID algorithm.

INJECTORS CAL.

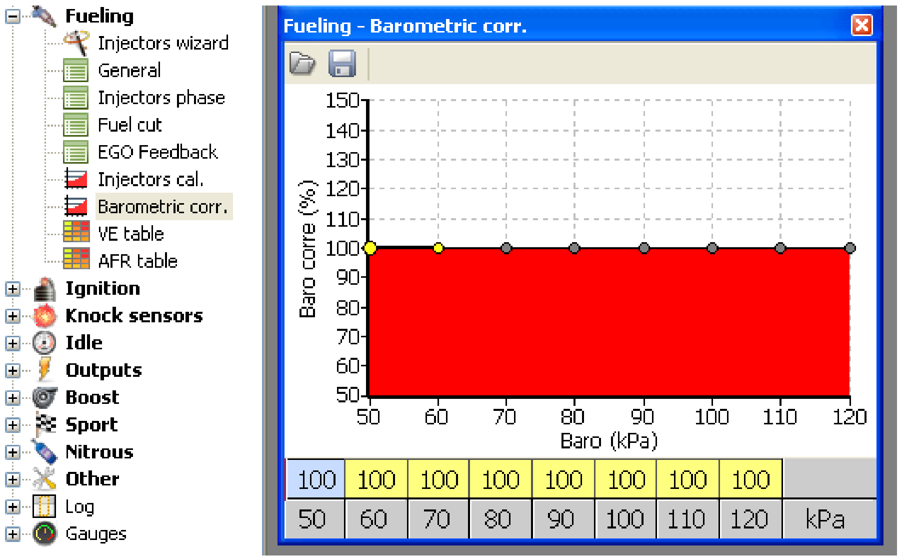


Injectors cal. map is used to calibrate the time of injector's opening in the function of voltage in the electrical system. The lower the voltage, the more time passes from energized injector's selenoid until it is fully open. These times are different depending on the type of injector and the fuel's pressure. The higher the pressure, the longer injector opens.

In case of popular injectors, we can use the *Injectors Wizard.*



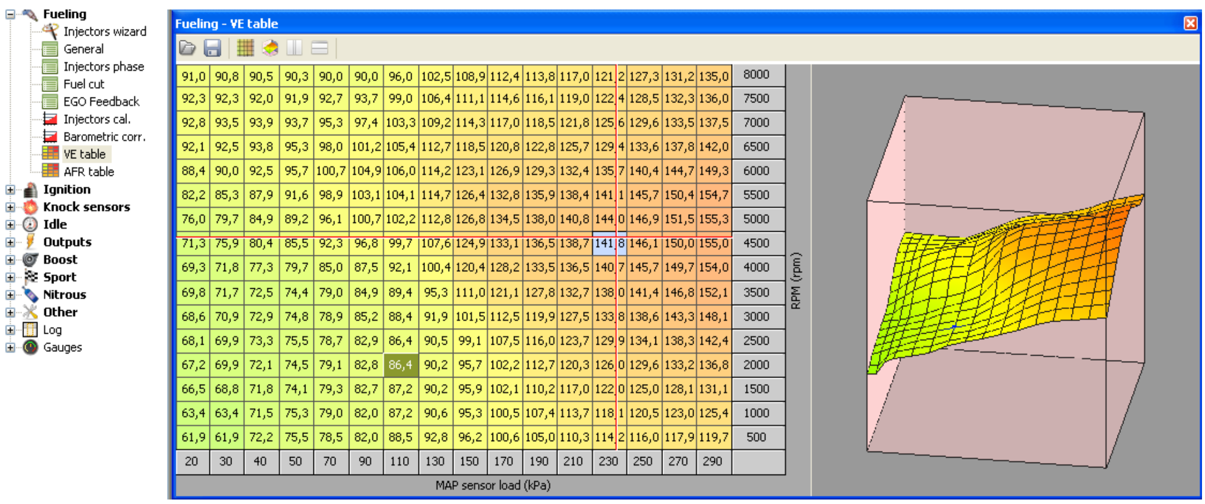
BAROMETRIC CORRECTION



100	100	100	100	100	100	100	100	
50	60	70	80	90	100	110	120	kPa

The table of barometric correction defines how the fuel dose will change depending on the barometric pressure. Used in the ALPHA-N algorithm. To activate this function you have to mark the *Enable Baro Connection* option in General options.

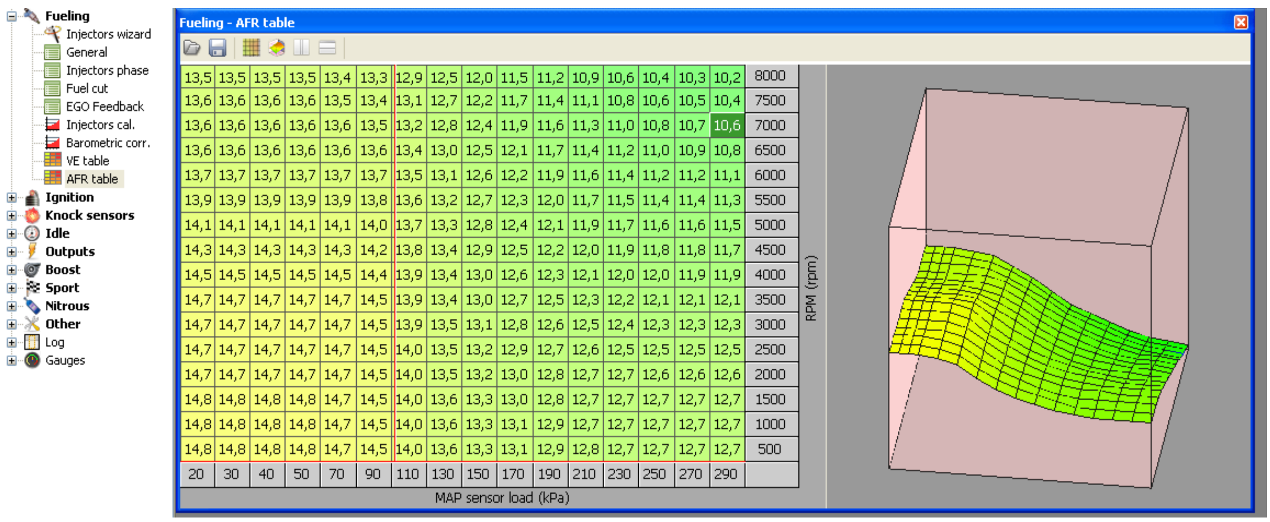
VE TABLE



91,0	90,8	90,5	90,3	90,0	90,0	96,0	102,5	108,9	112,4	113,8	117,0	121,2	127,3	131,2	135,0	8000
92,3	92,3	92,0	91,9	92,7	93,7	99,0	106,4	111,1	114,6	116,1	119,0	122,4	128,5	132,3	136,0	7500
92,8	93,5	93,9	93,7	95,3	97,4	103,3	109,2	114,3	117,0	118,5	121,8	125,6	129,6	133,5	137,5	7000
92,1	92,5	93,8	95,3	98,0	101,2	105,4	112,7	118,5	120,8	122,8	125,7	129,4	133,6	137,8	142,0	6500
88,4	90,0	92,5	95,7	100,7	104,9	106,0	114,2	123,1	126,9	129,3	132,4	135,7	140,4	144,7	149,3	6000
82,2	85,3	87,9	91,6	98,9	103,1	104,1	114,7	126,4	132,8	135,9	138,4	141,1	145,7	150,4	154,7	5500
76,0	79,7	84,9	89,2	96,1	100,7	102,2	112,8	126,8	134,5	138,0	140,8	144,0	146,9	151,5	155,3	5000
71,3	75,9	80,4	85,5	92,3	96,8	99,7	107,6	124,9	133,1	136,5	138,7	141,8	146,1	150,0	155,0	4500
69,3	71,8	77,3	79,7	85,0	87,5	92,1	100,4	120,4	128,2	133,5	136,5	140,7	145,7	149,7	154,0	4000
69,8	71,7	72,5	74,4	79,0	84,9	89,4	95,3	111,0	121,1	127,8	132,7	138,0	141,4	146,8	152,1	3500
68,6	70,9	72,9	74,8	78,9	85,2	88,4	91,9	101,5	112,5	119,9	127,5	133,8	138,6	143,3	148,1	3000
68,1	69,9	73,3	75,5	78,7	82,9	86,4	90,5	99,1	107,5	116,0	123,7	129,9	134,1	138,3	142,4	2500
67,2	69,9	72,1	74,5	79,1	82,8	86,4	90,2	95,7	102,2	112,7	120,3	126,0	129,6	133,2	136,8	2000
66,5	68,8	71,8	74,1	79,3	82,7	87,2	90,2	95,9	102,1	110,2	117,0	122,0	125,0	128,1	131,1	1500
63,4	63,4	71,5	75,3	79,0	82,0	87,2	90,6	95,3	100,5	107,4	113,7	118,1	120,5	123,0	125,4	1000
61,9	61,9	72,2	75,5	78,5	82,0	88,5	92,8	96,2	100,6	105,0	110,3	114,2	116,0	117,9	119,7	500
20	30	40	50	70	90	110	130	150	170	190	210	230	250	270	290	

VE table is the table of volumetric efficiency for the given load and RPM. In case of ALPHA-N algorithm, the load is defined by the throttle position sensor, while in the case of Speed Density algorithm through pressure in the intake manifold. Table resolution equals 0,1% VE.

AFR TABLE



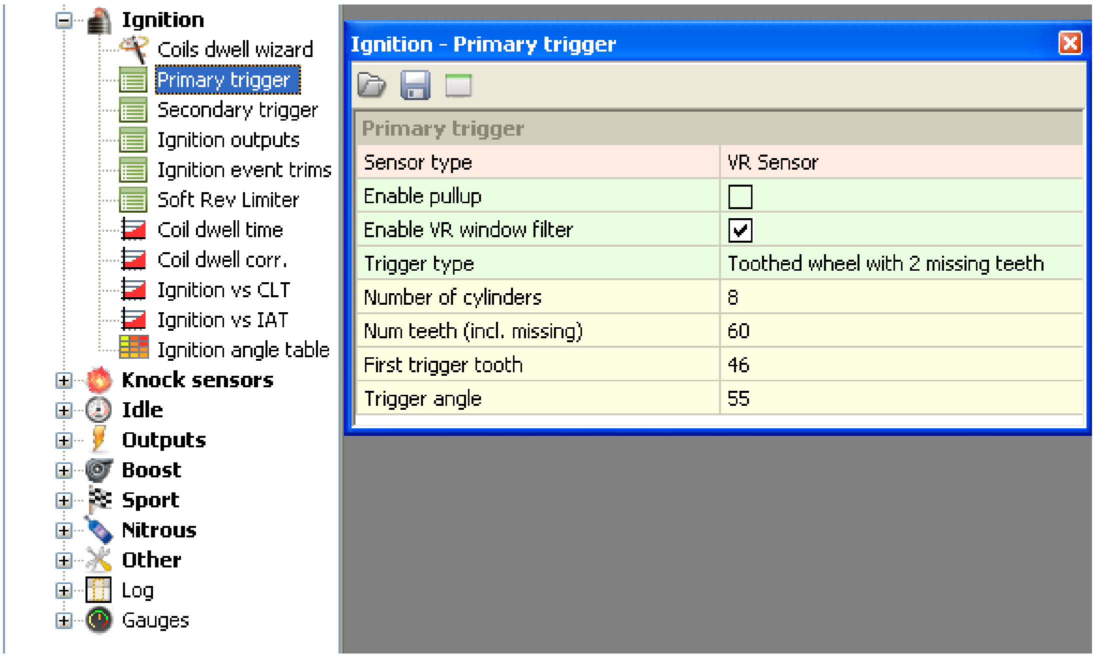
13,5	13,5	13,5	13,5	13,4	13,3	12,9	12,5	12,0	11,5	11,2	10,9	10,6	10,4	10,3	10,2	8000
13,6	13,6	13,6	13,6	13,5	13,4	13,1	12,7	12,2	11,7	11,4	11,1	10,8	10,6	10,5	10,4	7500
13,6	13,6	13,6	13,6	13,6	13,5	13,2	12,8	12,4	11,9	11,6	11,3	11,0	10,8	10,7	10,6	7000
13,6	13,6	13,6	13,6	13,6	13,6	13,4	13,0	12,5	12,1	11,7	11,4	11,2	11,0	10,9	10,8	6500
13,7	13,7	13,7	13,7	13,7	13,7	13,5	13,1	12,6	12,2	11,9	11,6	11,4	11,2	11,2	11,1	6000
13,9	13,9	13,9	13,9	13,9	13,8	13,6	13,2	12,7	12,3	12,0	11,7	11,5	11,4	11,4	11,3	5500
14,1	14,1	14,1	14,1	14,1	14,0	13,7	13,3	12,8	12,4	12,1	11,9	11,7	11,6	11,6	11,5	5000
14,3	14,3	14,3	14,3	14,3	14,2	13,8	13,4	12,9	12,5	12,2	12,0	11,9	11,8	11,8	11,7	4500
14,5	14,5	14,5	14,5	14,5	14,4	13,9	13,4	13,0	12,6	12,3	12,1	12,0	12,0	11,9	11,9	4000
14,7	14,7	14,7	14,7	14,7	14,5	13,9	13,4	13,0	12,7	12,5	12,3	12,2	12,1	12,1	12,1	3500
14,7	14,7	14,7	14,7	14,7	14,5	13,9	13,5	13,1	12,8	12,6	12,5	12,4	12,3	12,3	12,3	3000
14,7	14,7	14,7	14,7	14,7	14,5	14,0	13,5	13,2	12,9	12,7	12,6	12,5	12,5	12,5	12,5	2500
14,7	14,7	14,7	14,7	14,7	14,5	14,0	13,5	13,2	13,0	12,8	12,7	12,7	12,6	12,6	12,6	2000
14,8	14,8	14,8	14,8	14,7	14,5	14,0	13,6	13,3	13,0	12,8	12,7	12,7	12,7	12,7	12,7	1500
14,8	14,8	14,8	14,8	14,7	14,5	14,0	13,6	13,3	13,1	12,9	12,7	12,7	12,7	12,7	12,7	1000
14,8	14,8	14,8	14,8	14,7	14,5	14,0	13,6	13,3	13,1	12,9	12,8	12,7	12,7	12,7	12,7	500
20	30	40	50	70	90	110	130	150	170	190	210	230	250	270	290	

Afr Table indicates the desired AFR target for every engine speed and load point that the engine might operate. To use this table EGO Feedback must be active.

CONFIGURATION OF IGNITION PARAMETERS

Configuration of ignition parameters is crucial from the point of view of the correct engine work and should be performed with the utmost care.

PRIMARY TRIGGER



Primary trigger is responsible for the type of signal controlling the work of the ignition system and the base configuration of ignition timing.

Currently, there are supported signals from trigger wheel having from 12 to 60 symmetrical teeth. In case 1 or 2 teeth are missing, it is not required to have the camshaft position sensor, however this prevents the work in the full sequence of ignition and fuel.

Sensor type – type of sensor on the trigger wheel. The choice includes the magneto-inductive sensor (*VR Sensor*) and the Hall's / Optical sensor. In the second case you should also activate the *Enable pull-up* option.

Enable pullup – activates the 4,7K resistor between the input and +12V. Function is mainly used in case of optical sensors and Hall's sensors, which output is usually the open collector,

Enable VR window filter – digital filter for sensors of the magneto-inductive sensors. Should be used with care,

Trigger type – describes a kind of signal from the ring gear. Currently, there are 3 types available to chose from:

Toothed wheel with 2 missing teeth - trigger wheel with two missing teeth (e.g., popular system Bosch 60-2),

Toothed wheel with 1 missing tooth - trigger wheel with one missing tooth (e.g., popular Ford's system 36-1),
Multitooth – trigger wheel without missing teeth.

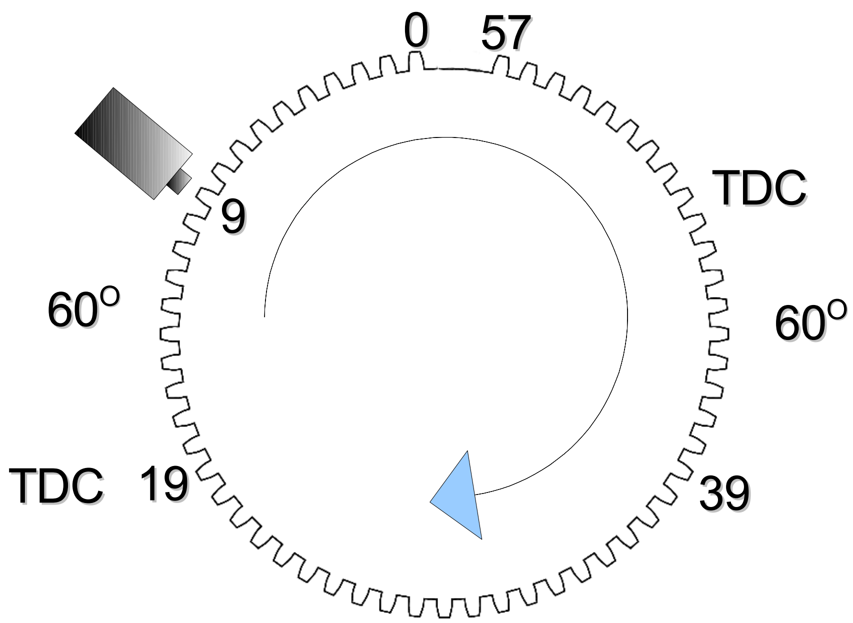
In next versions of the software the next types of trigger wheels will be implemented.

Number of cylinders – number of engine's cylinders. It also defines the number of ignition events, which number is equal to the number of cylinders,

Num teeth (incl. Missing) – number of teeth on the trigger wheel, including the missing teeth,

First trigger tooth - index of a tooth, which will mark out the first *Ignition Event*,

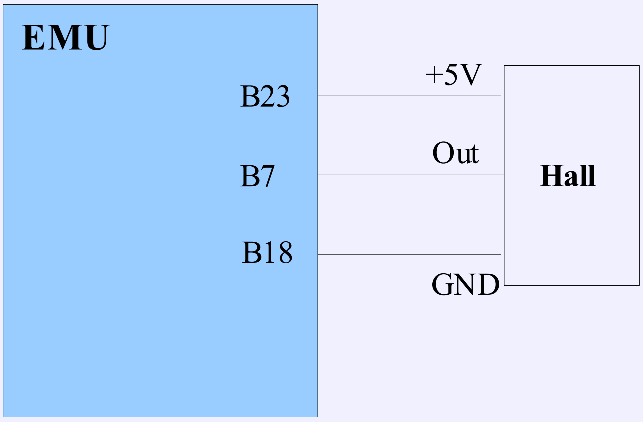
Trigger angle – the angle defining how many degrees before the TDC of a cylinder is the *first trigger tooth*. It is also the maximum spark advance. It should be usually within the 50-60 degrees range,



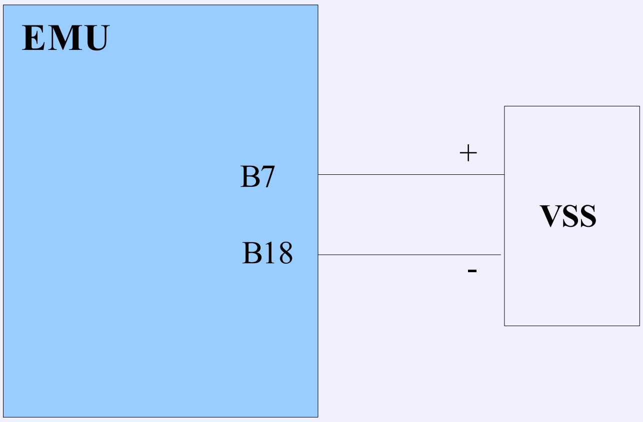
Sample ignition configuration for 60-2 trigger wheel

The above example of *Trigger Tooth* is defined as tooth 9, which is 60 degrees before TDC of the first cylinder (tooth 19). The next ignition event will fall out on tooth 39 (in the engine the 4 cylinder spark takes place every 180 degrees). I**t is crucial that *trigger tooth* for the next ignitron event does not fall on the place of the missing tooth (teeth)**! The configuration should be checked with the ignition timing light!

Depending on the type of the sensor, the scheme of connections looks as follows:



Hall's / Optical sensor connection

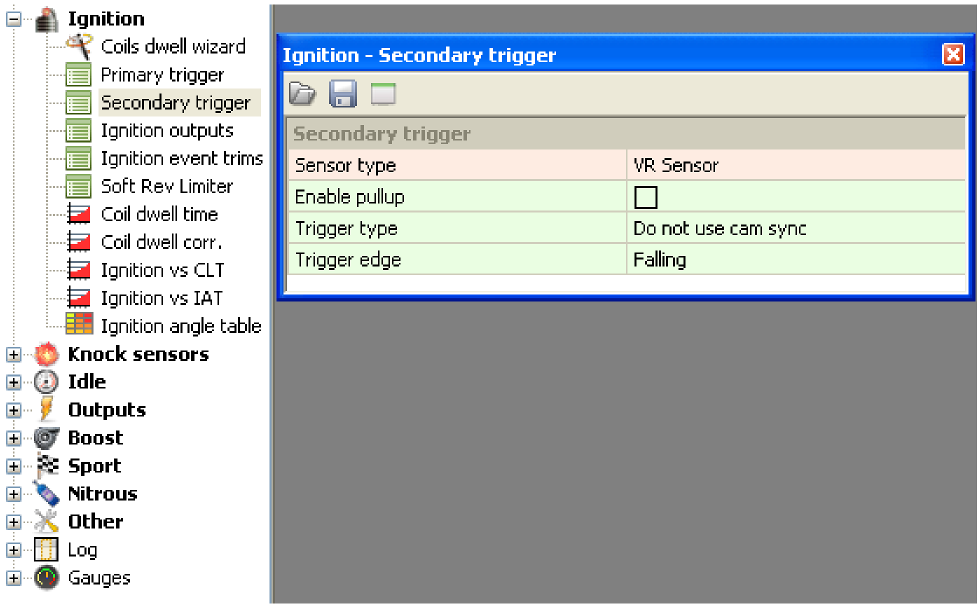


VR sensor connection

Uwaga !
In case of VR sensors connecting the sensor with the device must be done with the shielded cable, while the shield must be connected to the ground only at one end!

Uwaga !
In case of VR sensor the sensor's polarity is important!

SECONDARY TRIGGER



Secondary trigger is used to synchronize the ignition with the given cylinder, and what follows, it enables the work in the full sequence of ignition and fuel injection. The currently supported system of synchronization is the trigger wheel with one tooth placed on the camshaft. Both VR and Hall's / optical sensors are supported.

The selected edge of the signal informs the EMU device that the next *trigger tooth* will be the ignition event number 1. In case this does not suit the first cylinder, we should change the order of ignition outputs in the table of *Ignition outputs.*

Sensor type – type of sensor on the trigger wheel. The choice includes the magneto-inductive sensor (*VR Sensor*) and the Hall's / Optical sensor. In the second case you should also activate the *Enable pull-up* option.

Enable pullup – activates the 4,7K resistor between the input and +12V. Function is mainly used in case of optical sensors and Hall's sensors, which output is usually the open collector,

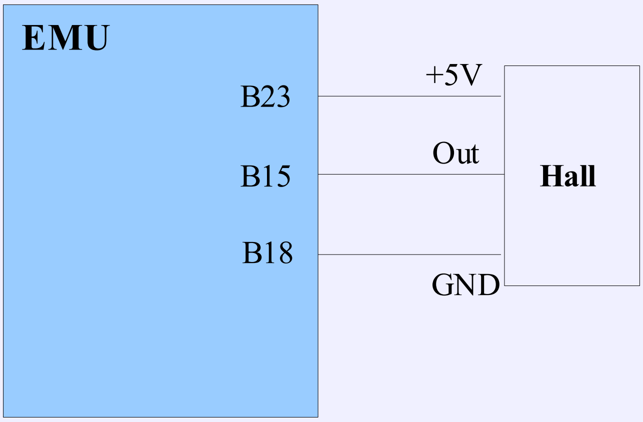
Trigger type – type of the trigger signal:

Do not use cam sync - do not use the synchronization of the camshaft position sensor,

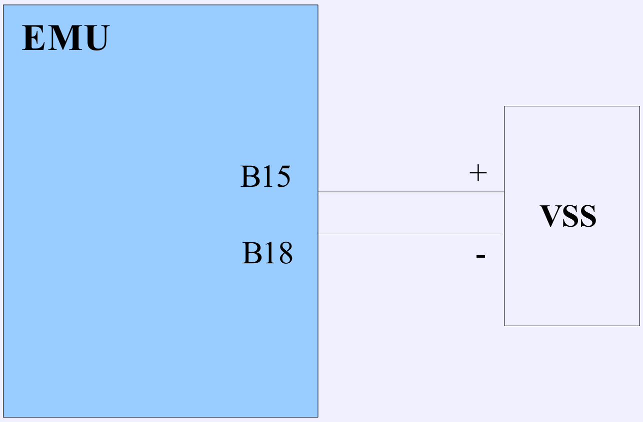
1 tooth cam sync - use the synchronization with the camshaft position sensor and trigger wheel with one tooth,

Trigger edge – edge of signal from the camshaft position sensor, to which the first ignition event will be synchronized.

Depending on the type of the sensor, the scheme of connections looks as follows:



Hall's / Optical sensor connection

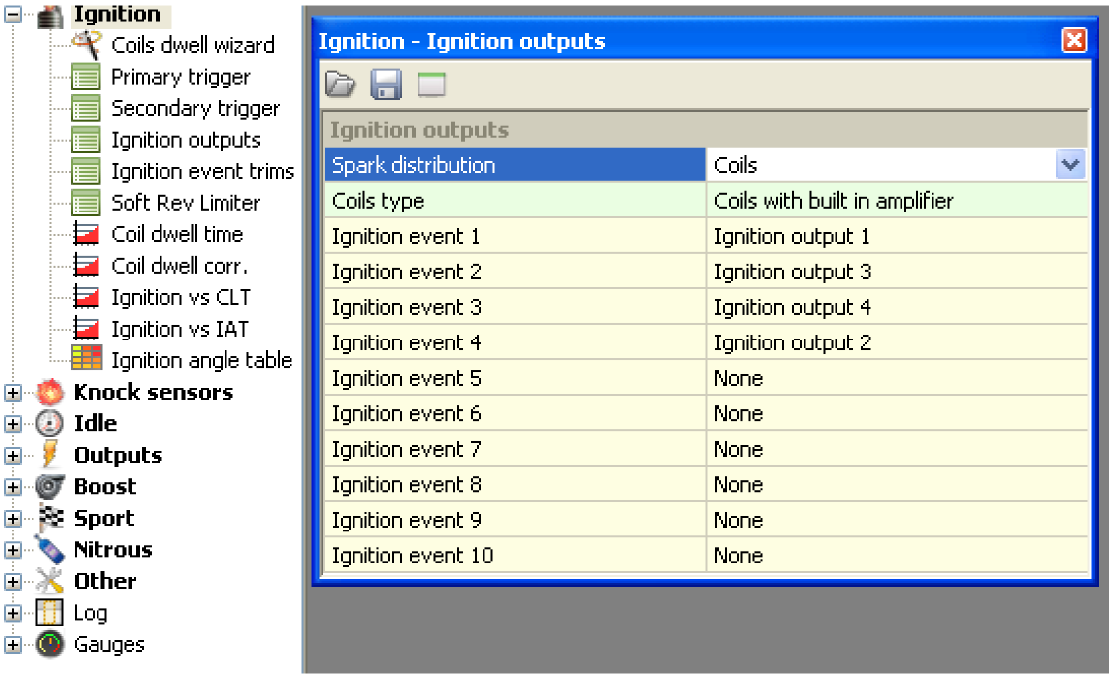


VR sensor connection

Uwaga !
In case of VR sensors connecting the sensor with the device must be done with the shielded cable, while the shield must be connected to the ground only at one end!

Uwaga !
In case of VR sensor the sensor's polarity is important!

IGNITION OUTPUTS



Ignition Outputs table is responsible for assignment of particular cylinders (or pairs of cylinders in case of *wasted spark*) to particular ignition events (*Ignition events*).

Spark distribution – determines whether the EMU device will use the ignition distributor (*Distributor*) or whether it will use ignition coils (distributorless systems), both single or double.

Coils type – defines the type of the used ignition coils. In case of passive coils without ignition modules we should choose the option of *Coils without amplifier*, in case of coils with the in-built ignition module or by using the external ignition modules, you should choose option of C*oils with built in amplifier.*

Uwaga !

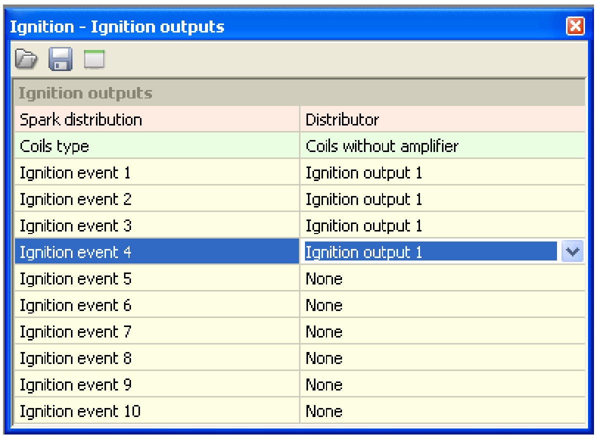
In case of passive coils, the choice of the option of *Coils with built in amplifier* will lead to the damage of coils or the EMU device!!!!

Uwaga !

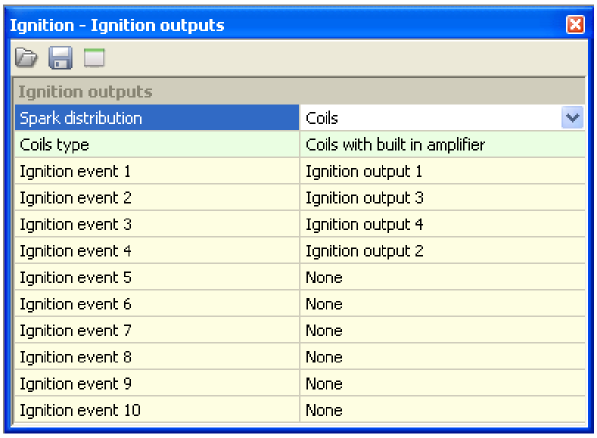
In case of passive coils, the device can become hot. You should provide the device with the way of getting rid of excessive heat.

In *ignition events* fields we have a chance to assign the appropriate ignition outputs to ignition events.

4-cylinder engine, 1 passive coil is connected to the ignition output #1, distributor.


Ignition - Ignition outputs

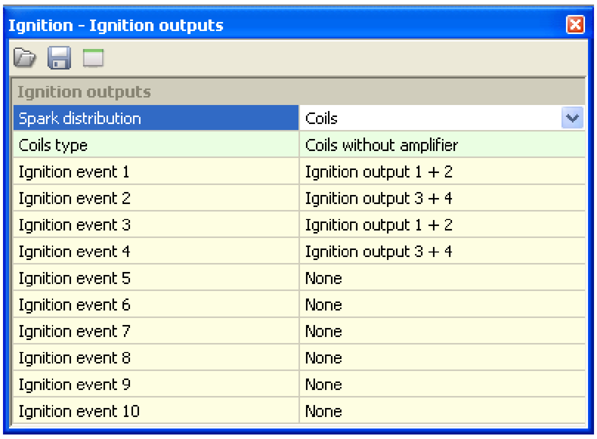
Ignition outputs	
Spark distribution	Distributor
Coils type	Coils without amplifier
Ignition event 1	Ignition output 1
Ignition event 2	Ignition output 1
Ignition event 3	Ignition output 1
Ignition event 4	Ignition output 1
Ignition event 5	None
Ignition event 6	None
Ignition event 7	None
Ignition event 8	None
Ignition event 9	None
Ignition event 10	None


Ignition - Ignition outputs

Ignition outputs	
Spark distribution	Coils
Coils type	Coils with built in amplifier
Ignition event 1	Ignition output 1
Ignition event 2	Ignition output 3
Ignition event 3	Ignition output 4
Ignition event 4	Ignition output 2
Ignition event 5	None
Ignition event 6	None
Ignition event 7	None
Ignition event 8	None
Ignition event 9	None
Ignition event 10	None

4-cylinder engine, full ignition sequence, order of cylinders' ignition 1-3-4-2, active coils connected in the following order: coil of the first cylinder to the ignition output #1, coil of the second cylinder to the ignition output #2, etc,

4-cylinder engine, wasted spark, ignition order 1-3-4-2, passive coils connected in the order: coil of the first cylinder to the ignition output #1, coil of the fourth cylinder to the ignition output #2, coil of the third cylinder to the ignition output #3, and coil of the second cylinder to the ignition output #4.

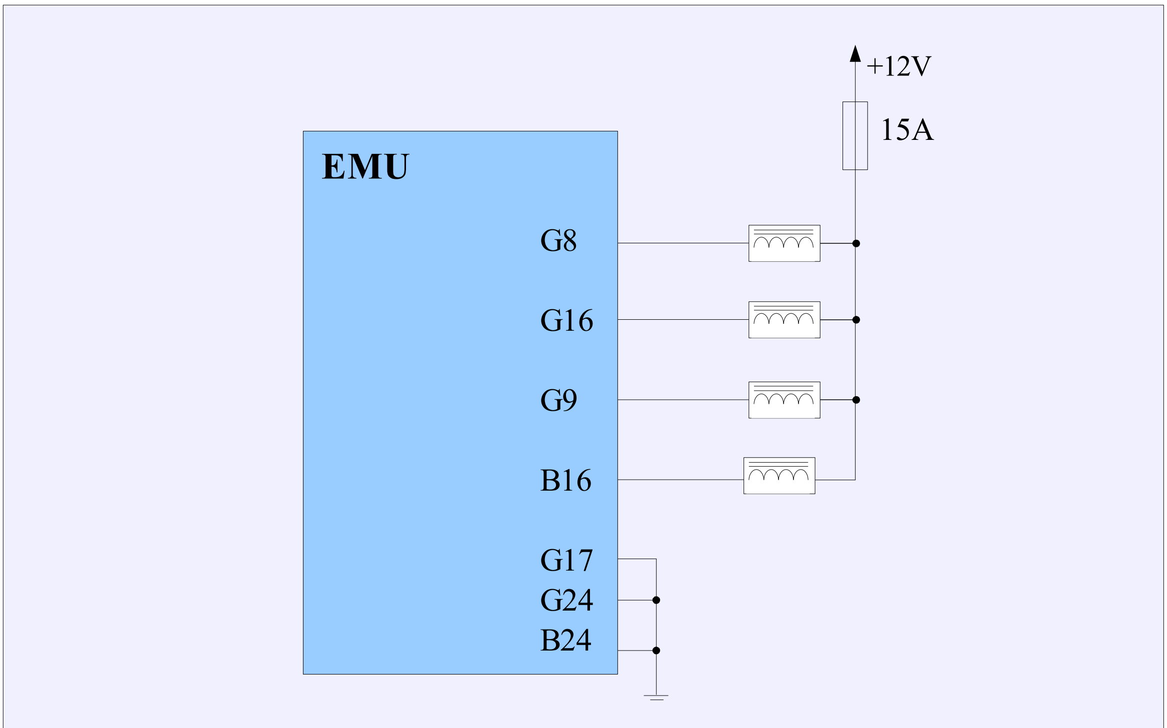

Ignition - Ignition outputs

Ignition outputs	
Spark distribution	Coils
Coils type	Coils without amplifier
Ignition event 1	Ignition output 1 + 2
Ignition event 2	Ignition output 3 + 4
Ignition event 3	Ignition output 1 + 2
Ignition event 4	Ignition output 3 + 4
Ignition event 5	None
Ignition event 6	None
Ignition event 7	None
Ignition event 8	None
Ignition event 9	None
Ignition event 10	None

In case when the first ignition event does not occur in the first cylinder, you should properly modify the table of *Ignition Outputs.* In the table below it is illustrated how the table of ignition outputs will look like in case of ignition sequence 1-3-4-2, when the first ignition event does not correspond to the first cylinder:

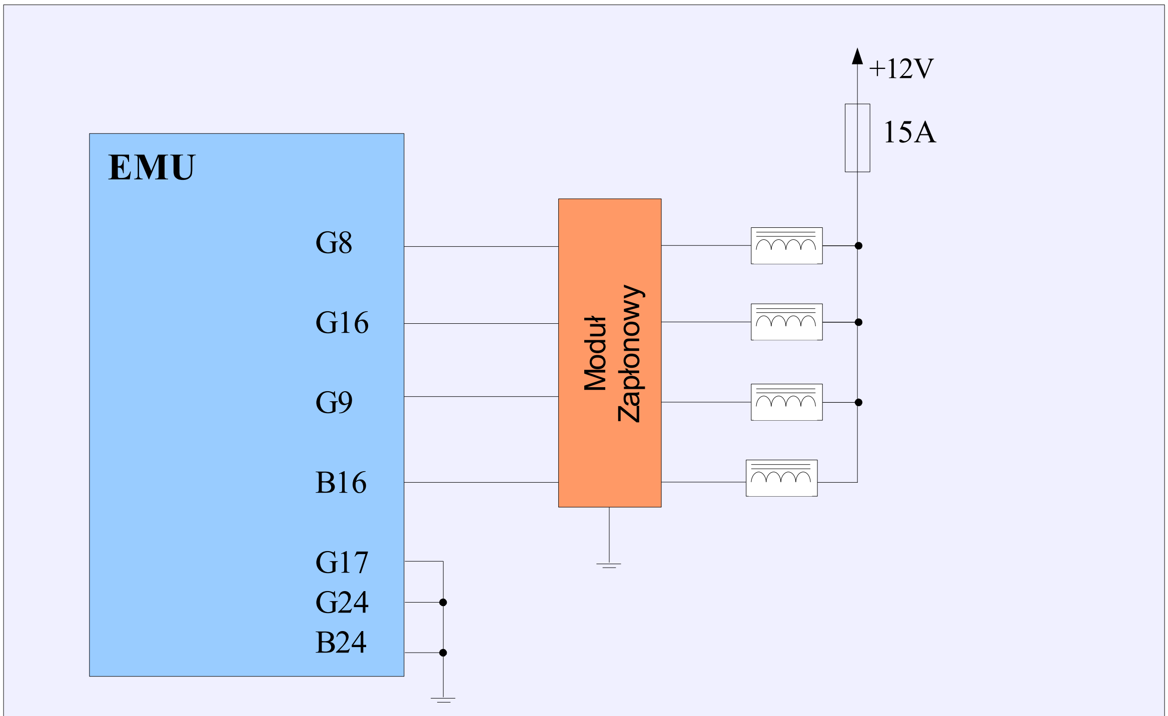
First cylinder	**Ignition Event 1**	**Ignition Event 2**	**Ignition Event 3**	**Ignition Event 4**
1	Ignition output 1	Ignition output 3	Ignition output 4	Ignition output 2
2	Ignition output 3	Ignition output 4	Ignition output 2	Ignition output 1
3	Ignition output 4	Ignition output 2	Ignition output 1	Ignition output 3
4	Ignition output 2	Ignition output 1	Ignition output 3	Ignition output 4

Example of connecting the ignition coils to the EMU device



Connection of 4 passive ignition coils

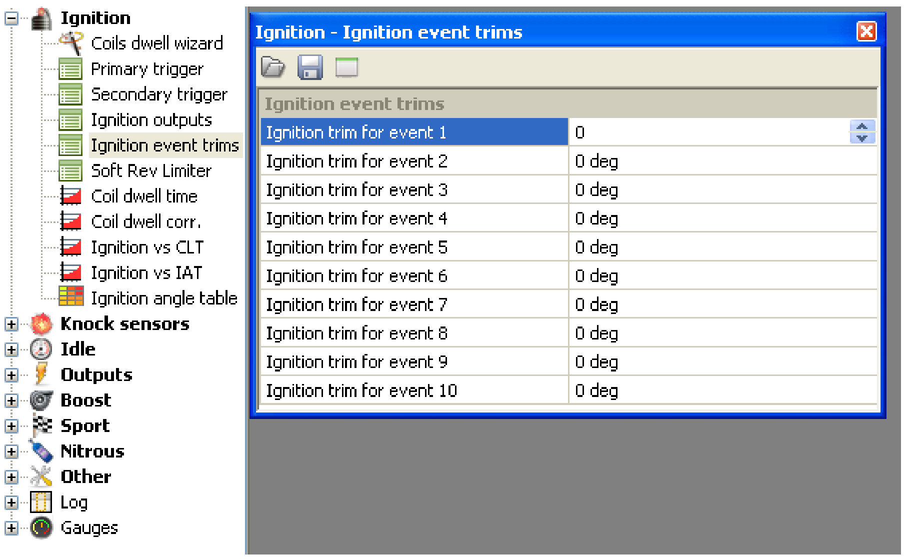
Uwaga !
In case of passive coils, you should never connect two coils to one ignition output.



Sample of connection of 4 passive coils using ignition module

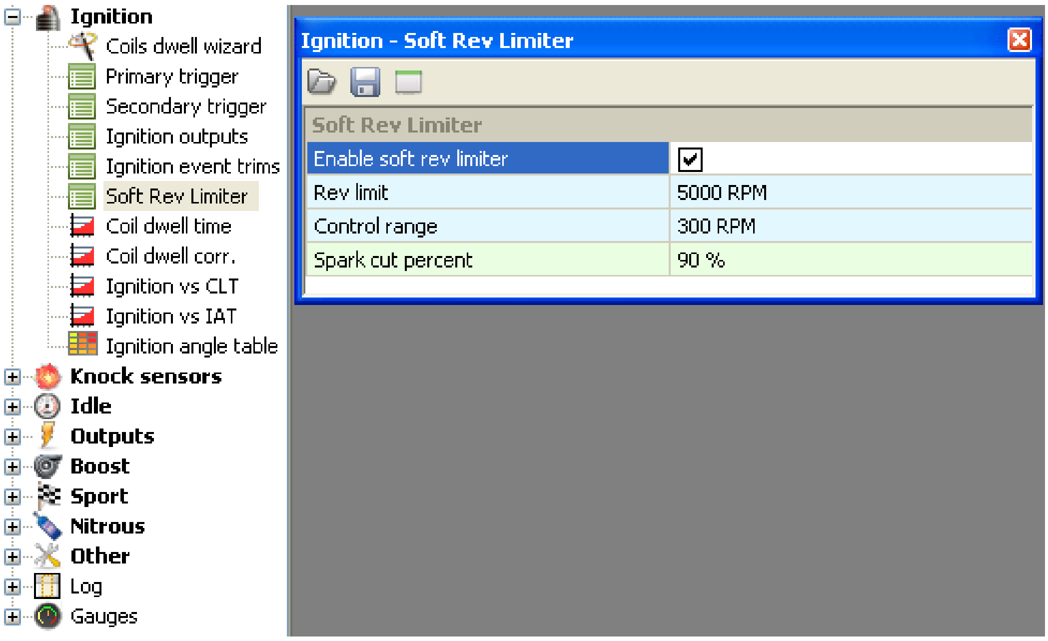
In case of active coils or using ignition modules, there is a chance to connect two coils or module inputs to one ignition output in order to do wasted spark ignition.

IGNITION EVENT TRIMS



For each ignition event you can introduce the angle correction of ignition advance by using the table of *Ignition event trims*.

SOFT REV LIMITER



Soft limiter of engine speed, as opposed to the limiter of engine speed based on fuel cut (*Fuel Cut*), enables the smooth RPM limitation. This limiter should be set below the *Fuel Cut* rev limiter.

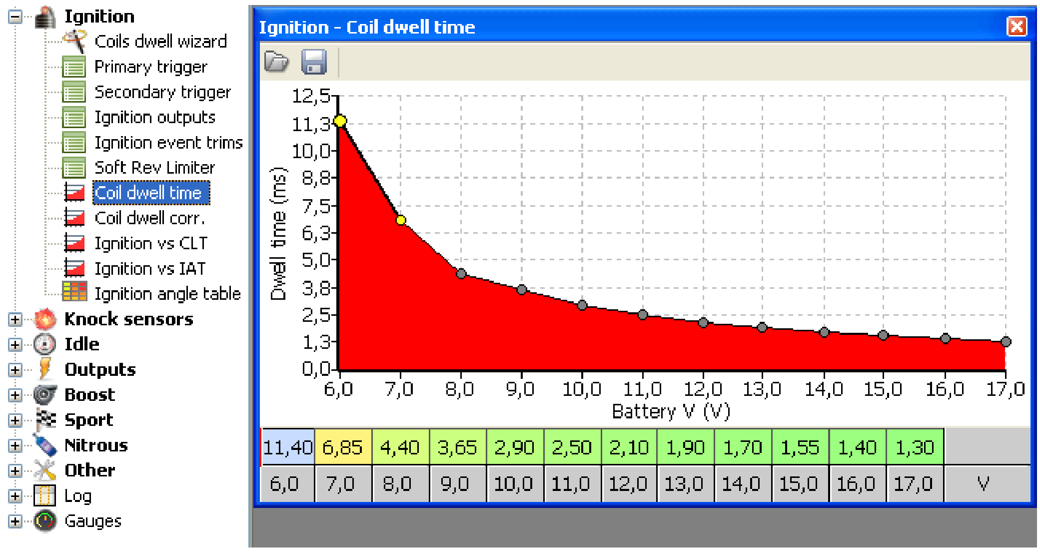
Enable soft rev limiter - activates function of the engine speed soft limiter,

Rev limit – value of limiter's RPM,

Control range – RMP range in which the spark cut takes place,

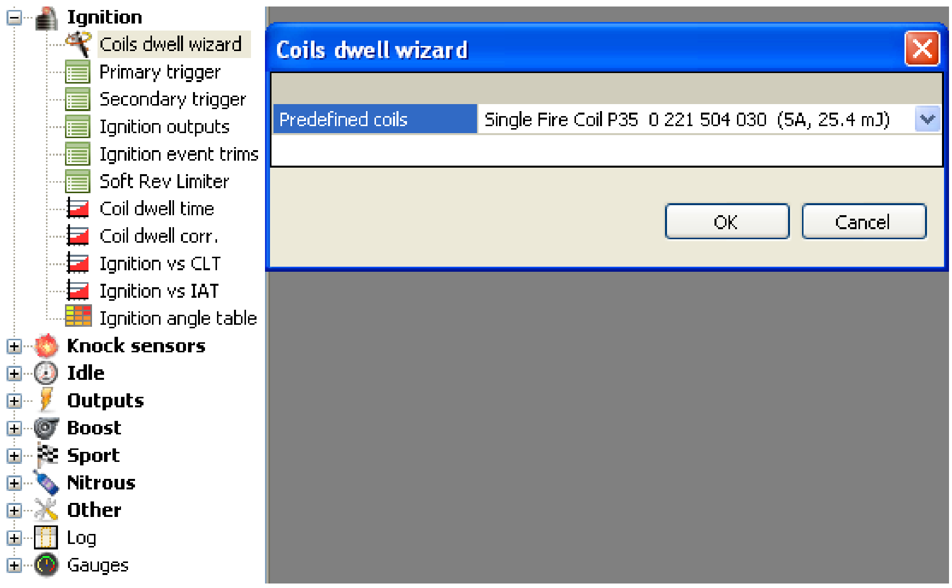
Spark cut percent – maximal number of sparks in percentage, which may be cut in order to maintain the RPM limit. If this value is too small, the algorithm will not be able to keep RPM limit.

COIL DWELL TIME



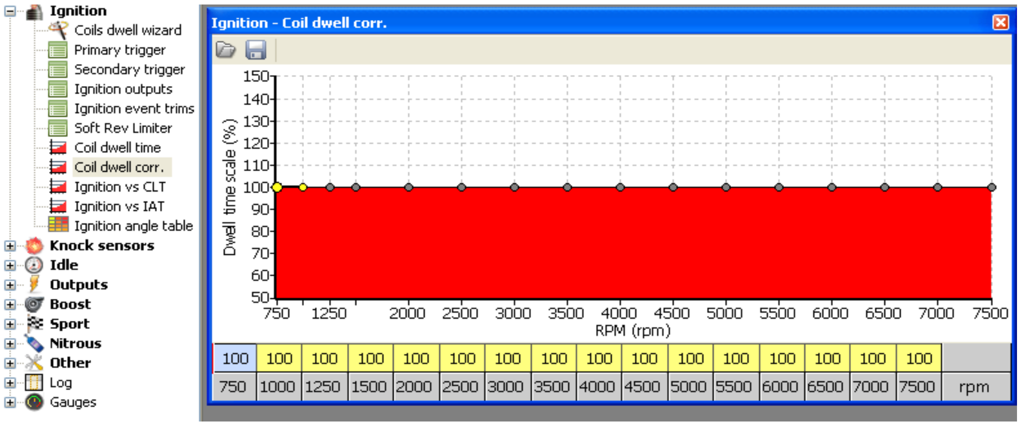
The coil dwell time table determines how long the ignition coil should be charged, depending on the voltage in the electrical system. The lower the voltage, the longer the time of charging. Too short time of coil charging will result in a weak spark and misfire, too long time will cause EMU and ignition coil overheating.

In order to create the coil dwell time table you should use the wizard (*Coils dwell wizard*) or use ignition coil manufacturer's data.



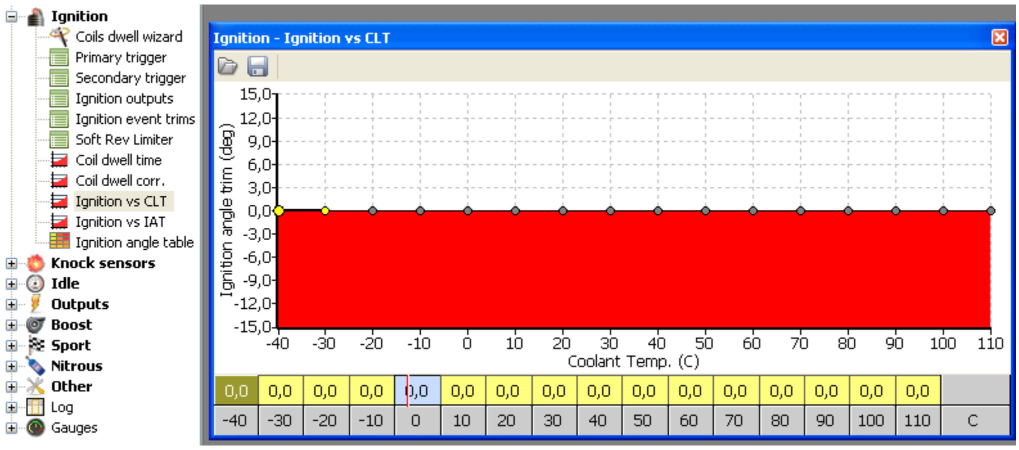
In the wizard we select the coil model from the list and accept it by clicking the OK button, what will cause the filling of *Coil dwell time* table with appropriate values.

COIL DWELL CORR.



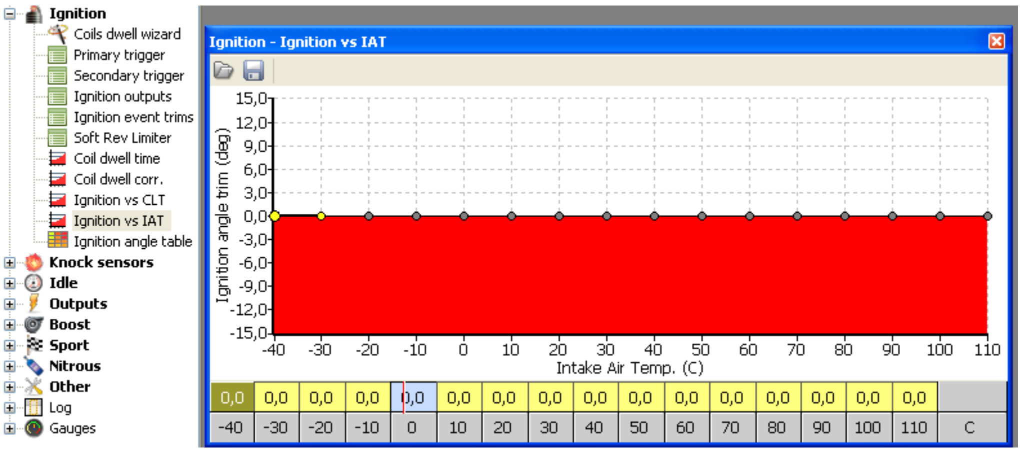
Coil dwell corr. table is used to correct the coil dwell time in the function of engine's speed.

IGNITION vs CLT



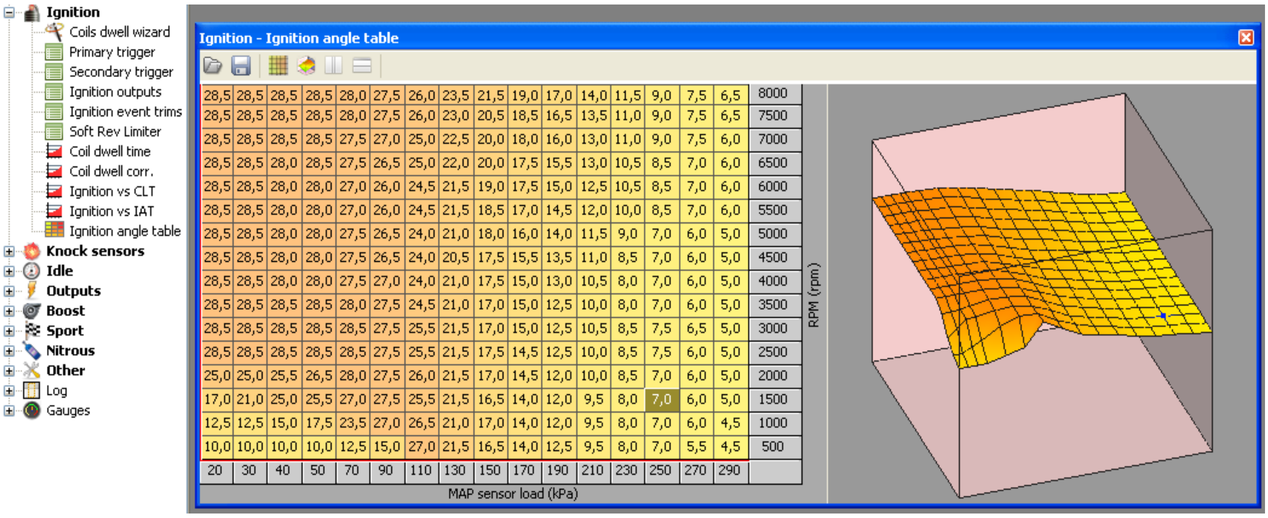
Ignition vs. CLT table determines the correction of the ignition advance in the function of temperature of the cooling liquid.

IGNITION vs IAT



Ignition vs. IAT table determines the correction of the ignition timing in function of the intake air temperature.

IGNITION ANGLE TABLE



I*gnition angle table* , is the main table of the ignition timing angle. Table's resolution is 0,5 degree. Positive values mean the angle before TDC, while negative values after TDC. The total angle of ignition advance is calculated as follows:

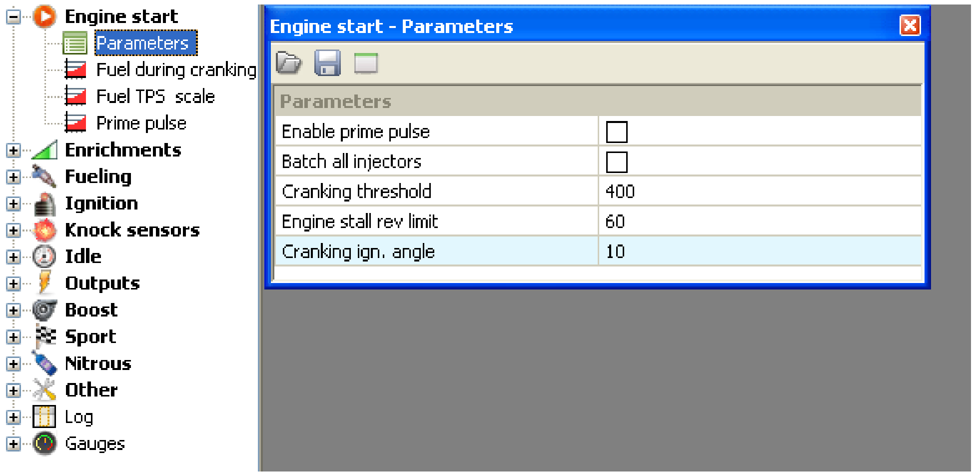
Angle = IGN(load,rpm) + CYLCorr(cyl) + IATCorr + CLTCorr + KSCorr + IDLECorr + LCCorr + Nitro(load, rpm)

IGN(load,rpm)	angle value of the ignition advance from the ignition table
CYLCorr(cyl)	correction of the ignition timing in cylinder function
IATCorr	correction of the ignition timing towards the intak air temperature
CLTCorr	correction of the ignition timing towards the cooling liquid temperature
KSCorr	correction of the ignition timing due to the occurrence of engine knock,
IDLECorr	correction of the ignition timing by the idle function,
LCCorr	correction of the ignition timing with the activation of the *Launch Control* function
NITRO(load,rpm)	correction of the ignition timing from the table of nitrous ignition mod.

CONFIGURATION OF ENGINE START PARAMETERS

Settings in the parameter group *Engine Start* are used in the start-up phase of the engine.

PARAMETERS



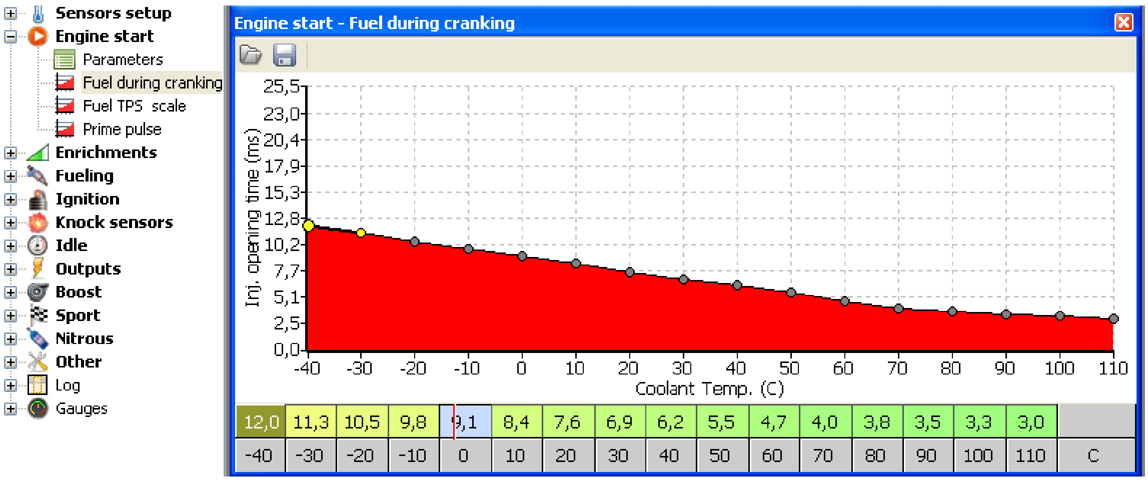
Enable prime pulse – activates the prime pulse function, so the additional fuel is injected whene device is turn on. It is injected before starting the motor, so the fuel has the time to evaporate, what makes starting engine easier. The size of the prime pulse is defined in the *Prime Pulse* table.

Batch all injectors – turning on this option will make all injectors active the same time during cranking (work in the full group mode). This option usually makes starting engine easier. In case of small injectors, using this option may be necessary.

Cranking treshold – RPM value when the device changes the working mode from *Cranking* to *After-start*. Above these RPM the engine starts working by using the VE tables and all enrichments and corrections. This value must be set higher than the engine’s speed while cranking.

Engine stall rev limit – engine speed below which the device states that the engine stops working and is initializing to the state after being turned on.

FUEL DURING CRANKING

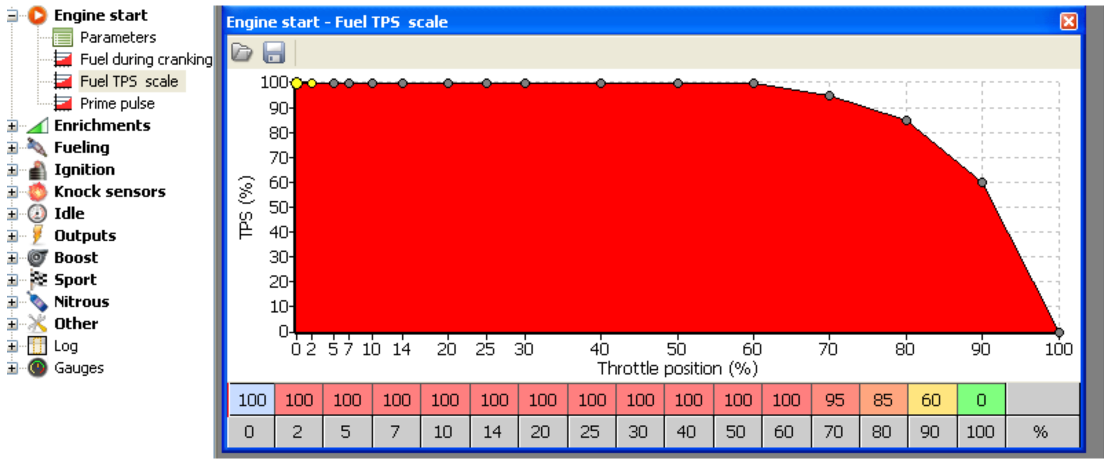


This table defines the starting fuel dose expressed in *ms*, in function on the engine's temperature. The higher the temperature, the lower the dose. For temperature -40˚C the dose should be about three times higher than for temperature 70˚C.

Uwaga !

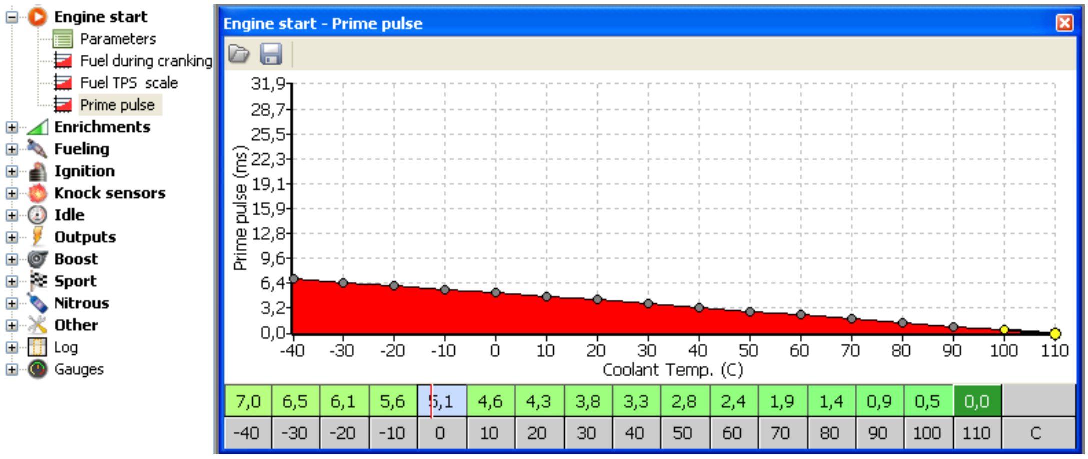
Too high values of the starting dose may lead to engine flooding, making it difficult for spark plugs to ignite the compressed mixture. For this reason, you should start from short times and extend them until you reach the optimal engine start up.

FUEL TPS SCALE



This table determine how the values from the *Fuel during cranking* table should be scaled, depending on the current TPS position. In case of 100% opening of the throttle, the 0% value is applied, what functions as the *anti flood,* so it prevents the spark plugs from flooding and allows the cleaning of the combustion chamber from the excessive fuel.

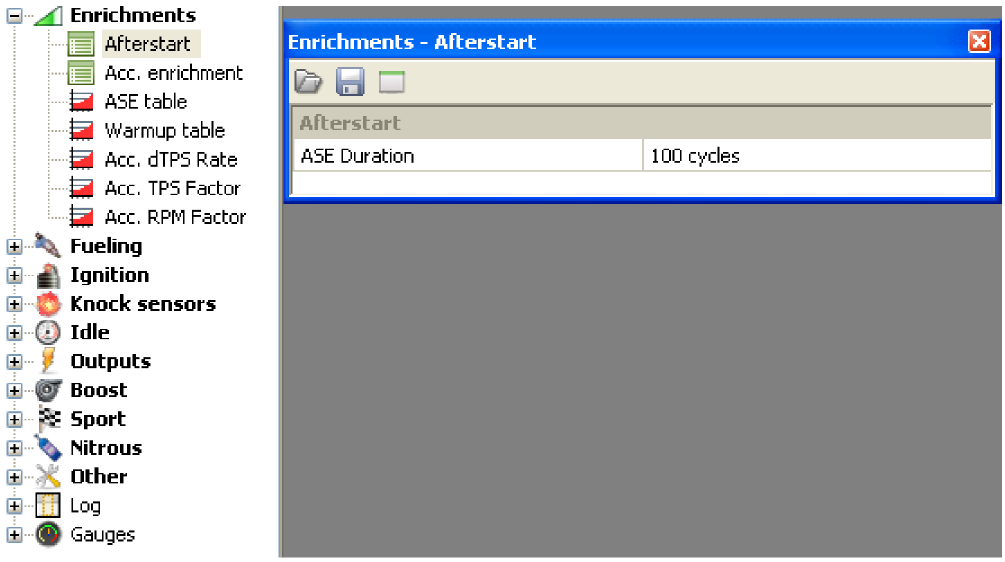
PRIME PULSE



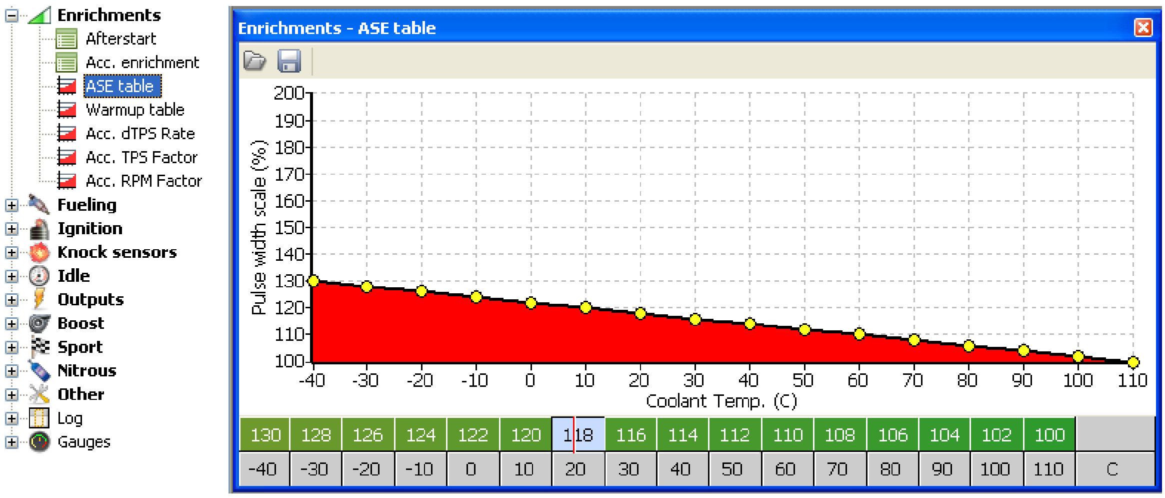
This table defines the injectors' opening time during of the *Prime pulse*. This function should be additionally activated in Parameters options (*Enable Prime Pulse*). The lower the temperature of the engine, the higher the time of *prime pulse*.

KONFIGURACJA PARAMETRÓW ENRICHMENTS

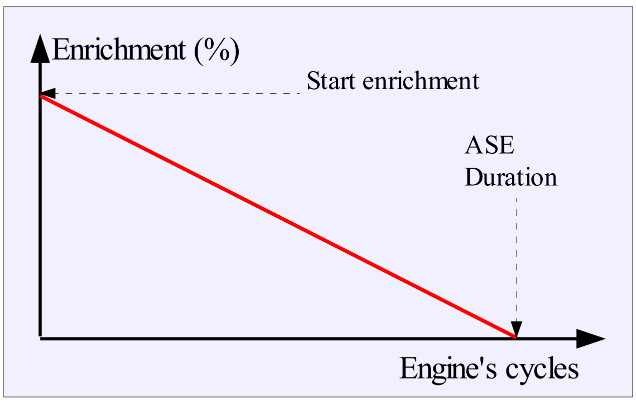
AFTERSTART



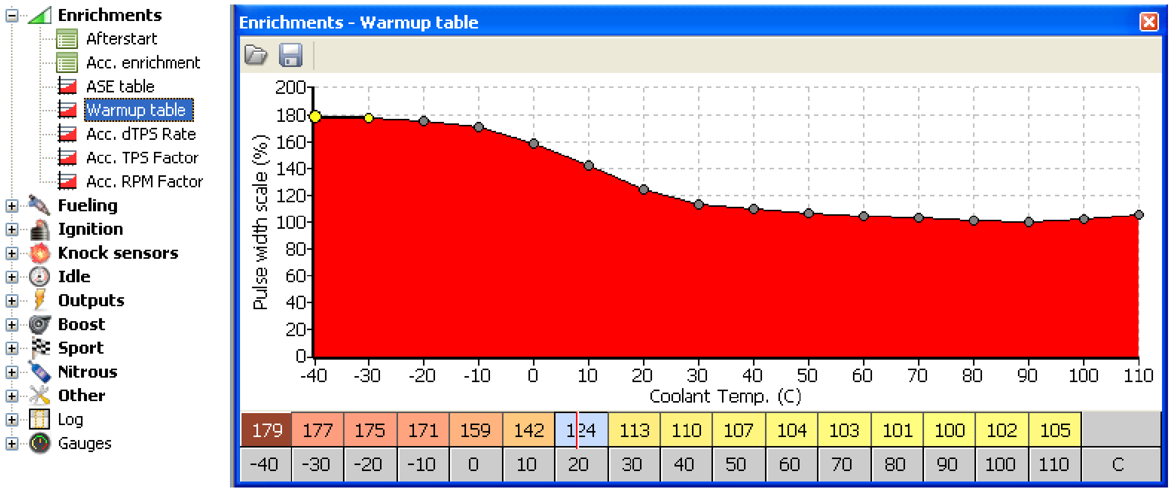
When the engine starts, the *After-start Enrichment* phase begins, in which the additional enrichment of the fuel dose is active in order to maintain stable engine revolutions. This enrichment depends on the temperature of the cooling liquid (the colder the engine, the bigger the enrichment). 2D table of this enrichment has the name of *ASE table.*



ASE Duration parameter is the time in engine's work cycles through which the After-start enrichment takes place. It should be emphasized that with each cycle of engine's work, this enrichment gets smaller in the linear way.

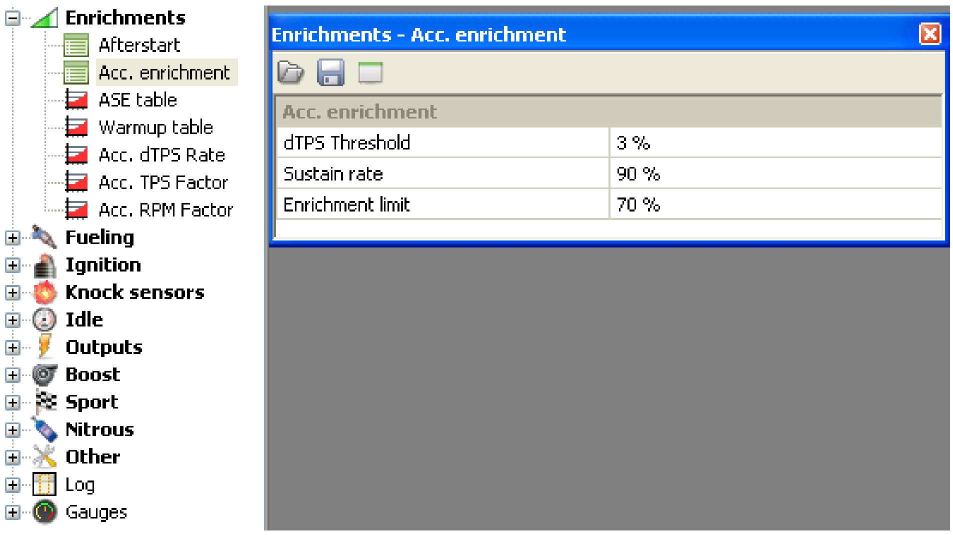


WARMUP TABLE



Enrichment of the fuel dose in the function of the cooling liquid temperature is used to compensate the fact that fuel in low temperatures doesn't evaporate well. When the engine gets working temperature, enrichment should equal 100% (lack of enrichment). For the additional protection of the engine from overheating, we can introduce additional enrichment of the mixture above the working temperature (additional fuel in many cases may help cool the engine).

ACCELERATION ENRICHMENT



During acceleration (rapid opening of the throttle plate) the rapid change of pressure in the intake manifold takes place, and what follows is the air flow, what leads to the temporary leaning of the mixture and the impression of the car poor acceleration. To prevent this phenomenon we use the so-called *Acceleration Enrichment*. It is calculated based on the speed of throttle position angle's change, current angle of throttle's plate and current engine speed.

Parameters of **Acceleration enrichment**

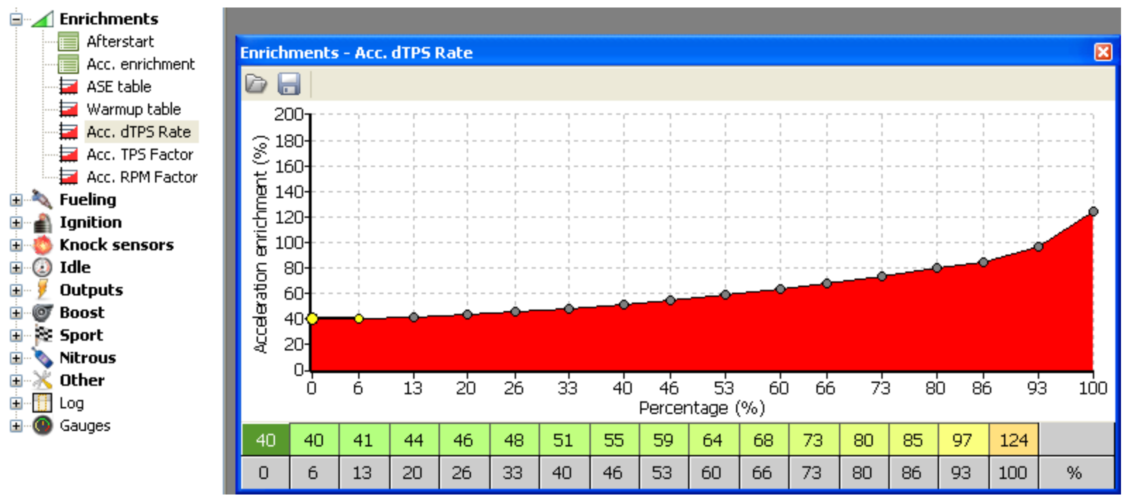
dTPS Threshold - change of dTPS values (speed of throttle plate angle's change) below which the mixture enrichment is not applied. This value aims at eliminating the enrichment connected with the noise of signal from the throttle position's sensor.

Sustain rate – determines the rate at which the acceleration enrichment goes away. The higher the value, the longer last the enrichment.

Enrichment Limit – maximal enrichment of the mixture calculated by the function of *Acceleration enrichment.*

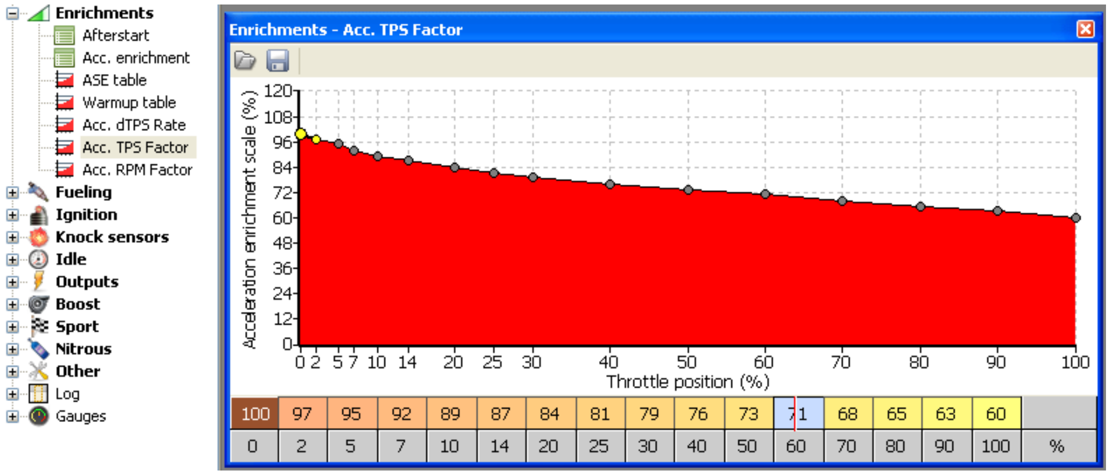
Three 2D tables are connected with the function of *Acceleration enrichment*.

Acc. DTPS Rate



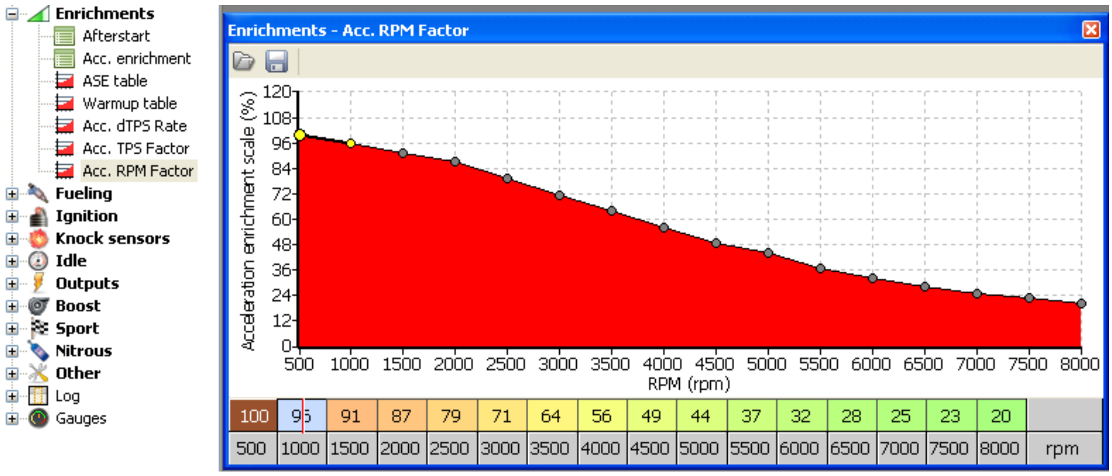
This table defines how much the fuel dose will be enrich in the function of change of the throttle plate angle (dTPS). The faster the change of this angle, the greater the enrichment.

Acc. TPS Factor



This table defines how the value from the table of *Acc. dTPS rate* should be scaled depending on the current throttle angle. The higher the throttle angle, the smaller the enrichment.

Acc. RPM Factor

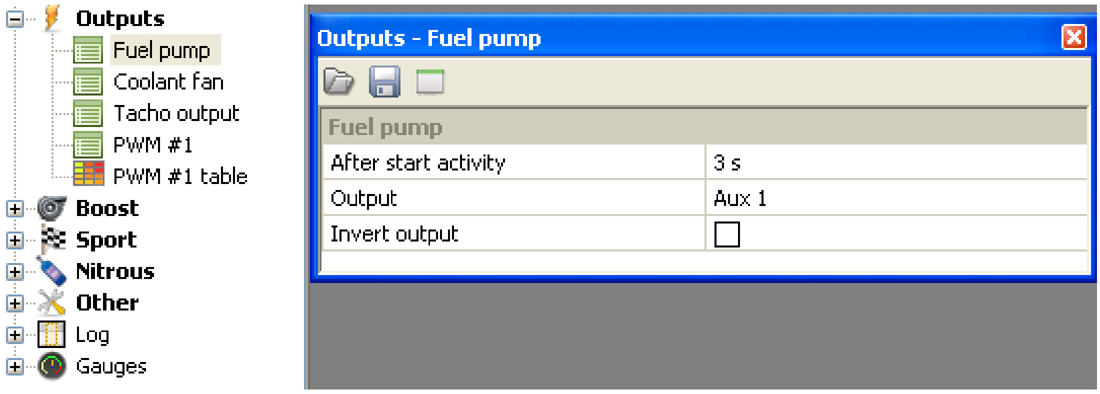


This table defines how the value resulting from the table of *Acc. dTPS rate* should be scaled depending on the engine's speed. The higher the engine speed, the lower the value of the enrichment.

Acc enrichment = Acc. dTPS rate(dTps) * Acc. RPM Factor(rpm) * Acc. TPS Factor(tps)

CONFIGURATION OF OUTPUTS PARAMETERS

FUEL PUMP



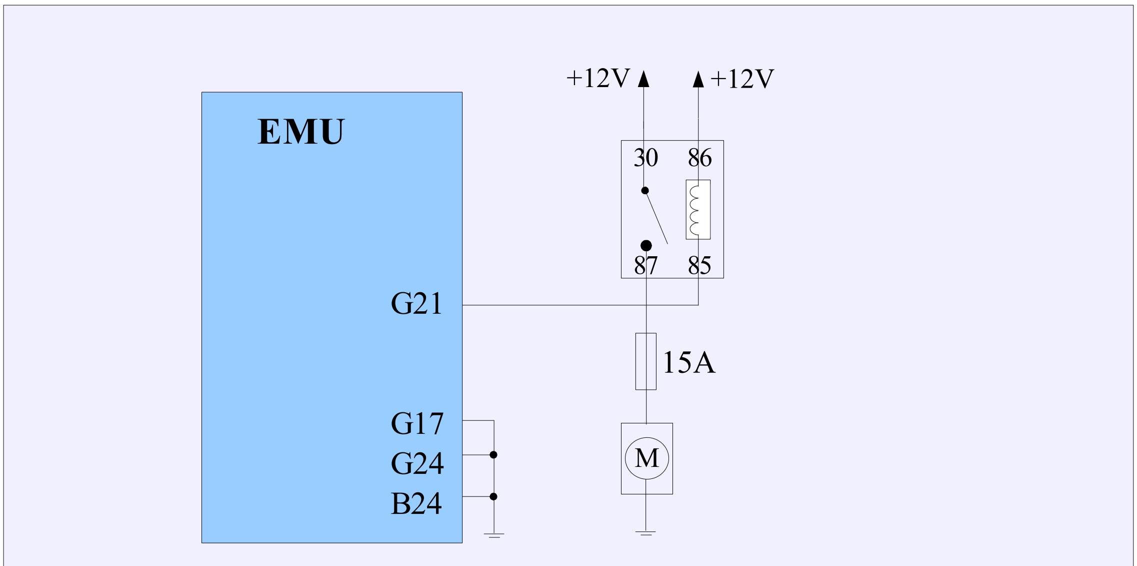
Configuration of *Fuel Pump* determines the output and parameters of controlling the fuel pump:

After start activity - determines the time for which the fuel pump will be activated after turning on the ignition. This time must be long enough to achieve the nominal pressure in the fuel line.

Output – name of the output to which we connect the relay controlling the fuel pump,

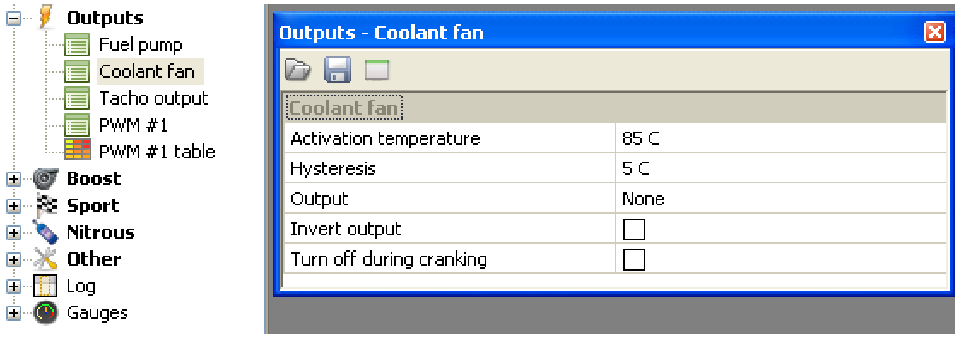
Invert output – reversal of the output. It can be used to test the actions of the fuel pump,

Fuel pump should be connected with using the relay and the appropriate fuse (10-20A)



Sample connection of fuel pump

COOLANT FAN



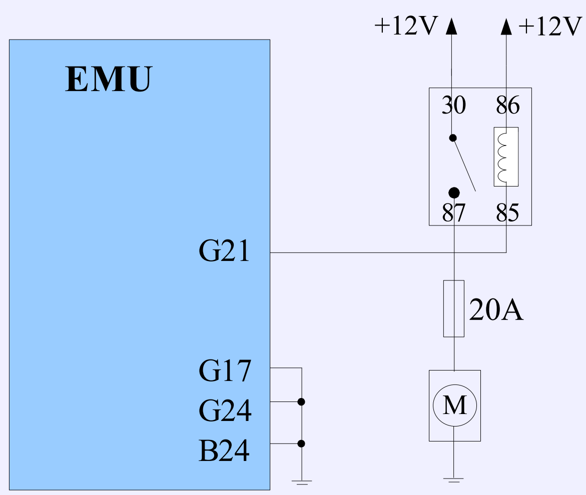
The support of the coolant fan is performed by the *Coolant Fan* function.

Activation temperature – temperature of activating the coolant fan,

Hysteresis – hysteresis defines how much the temperature must fall below *Activation Temperature* to turn off the fan,

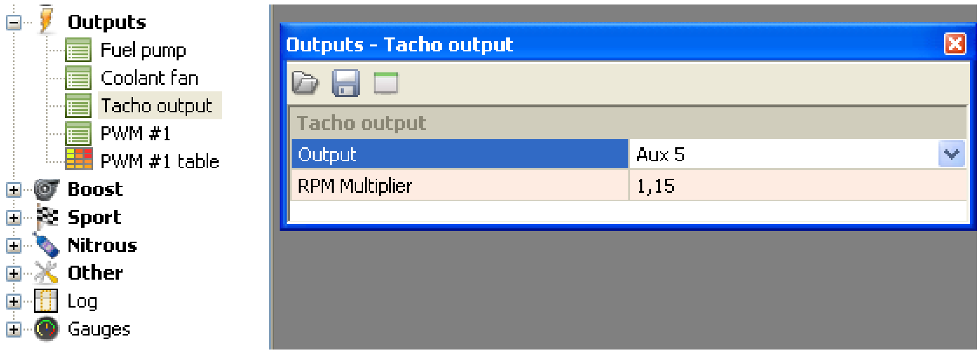
Output – name of the output to which we connect the relay controlling the fan,

Invert output – reversal of the output. It can be used to test the fan's actions.



Sample connection of coolant fan

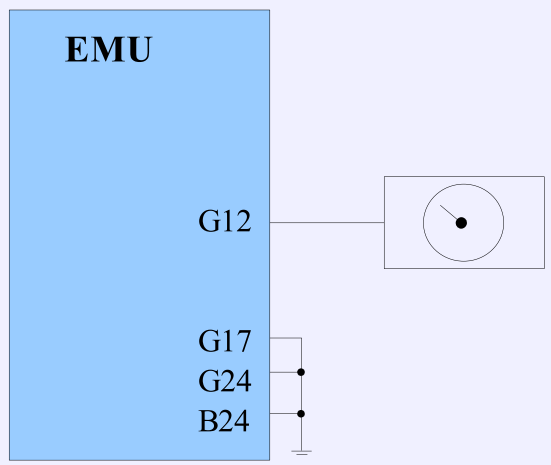
TACHO OUTPUT



Tacho Output function is used to control the electronic tachometers. Based on the engine speed it generates the square wave with the frequency proportional to the RPM. Tachometer should be connected to the Aux 4 output which is equipped with 10K resistor connected to +12V. In case of a different output, you should use an external pull-up resistor.

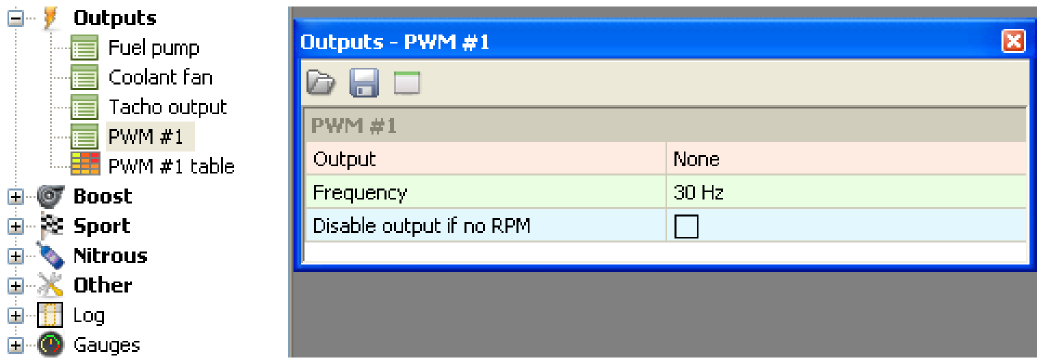
Output – device's output to which the tachometer is connected,

RPM Multiplier – value scaling the output frequency.



Sample connection of tachometer

PWM #1



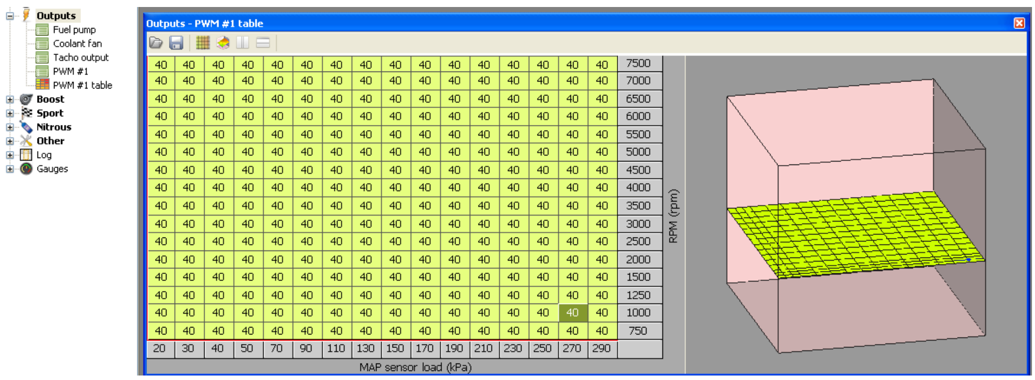
PWM #1 function is used to control the external solenoid valve using PWM signal, with the duty cycle defined in the 3D table.

Output – device's output to which the solenoid valve is connected,

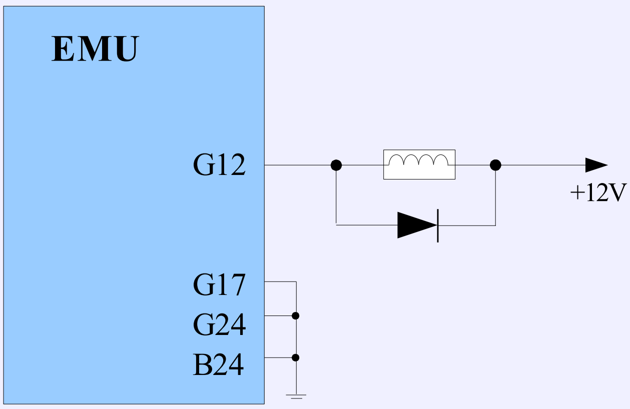
Frequency – frequency of the PMW signal,

Disable output if no RPM – if the engine does not work, the PWM output is turned off (DC = 0)

The duty cycle of PWM signal is defined in the 3D table *PWM #1 Table*,



In case of solenoid valves with large power consumption or high PWM frequency, you should use the external Flyback diode.

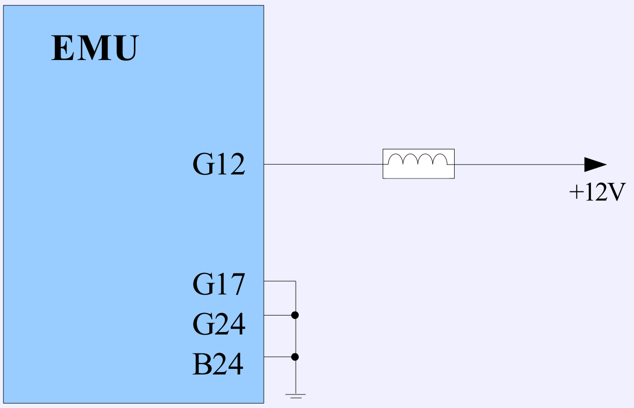


Sample connection of PWM controlled selenoid with flyback diode

CONFIGURATION OF IDLE PARAMETERS

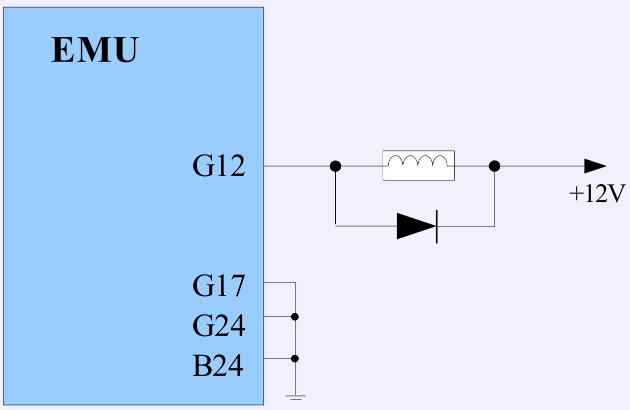
Idle control is responsible for the regulation of the engine idle speed. Due to the changing performance of the engine depending on its temperature, and also the change of its load by the external devices (alternator, air-conditioning, etc.) it is necessary to introduce the correction of the amount of the air flow on the idle speed. This function can be accomplished by the change of air dosage – the change of throttle position angle or the electro valve plugged in the by-pass system. We distinguish the following types of air valves:

ON/OFF – such valve has only two conditions: on and off. It is always a by-pass. Valves of such type occur in old cars and it is a rarely used solution.



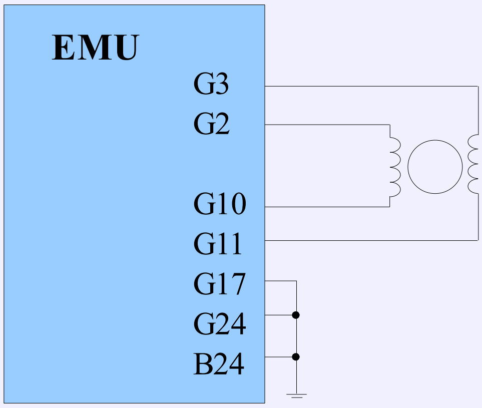
Sample connection of ON/OFF valve

PWM – valve with the possibility of the smooth change of opening through the modulation of impulses' width. It is always a by-pass. Usually the increase of the duty cycle causes the increase of the amount of air flowing through the valve. In case of valves controlled by high frequency (e.g., Bosch 0280 140 512) you should use the external flyback diode.



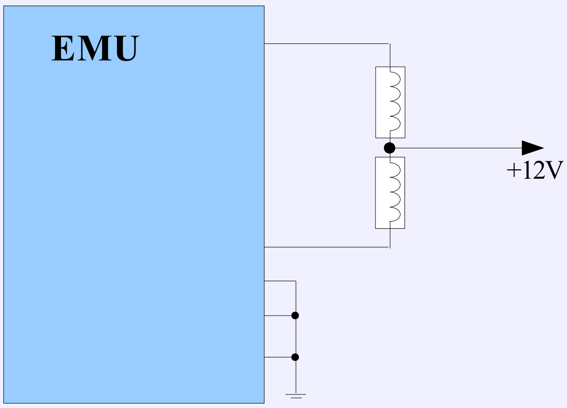
Sample connection of PWM valve with flyback didoe

Stepper motor – valve, which performing element is the stepper motor. It only requires the power supply during the change of the stepper motor position.



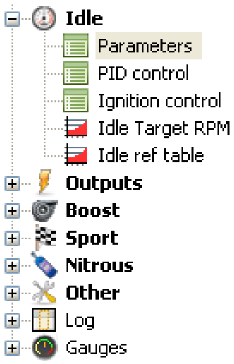
Sample connection of PWM stepper motor

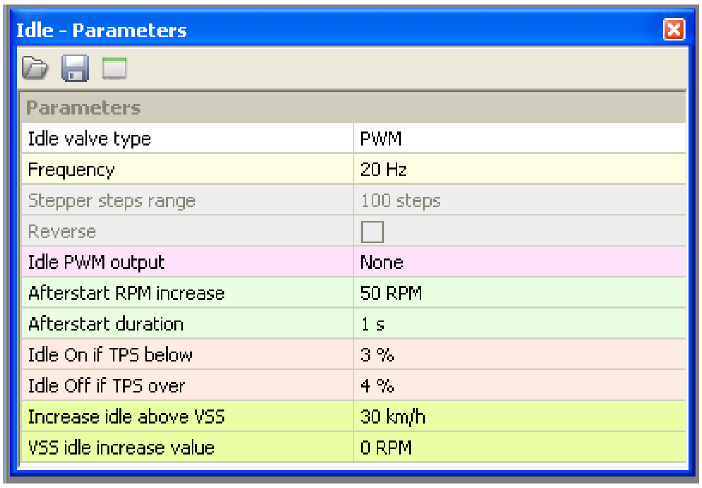
3 Wire PWM – valve using two windings (e.g., Bosch 0280 140 505). When it is not powered, it is in the middle position. Depending on which winding is powered, the valve will get more closed or opened.



Sample connection of 3 wire PWM valve

IDLE PARAMETERS

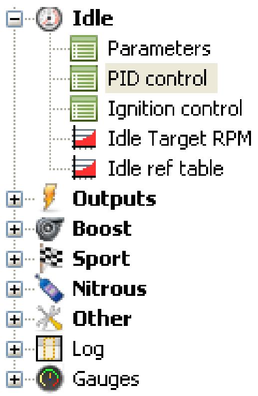


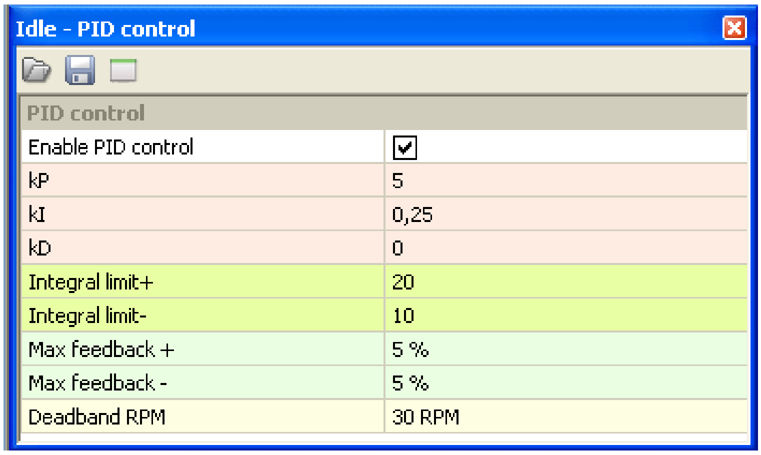


The basic configuration of control of engine idle speed is in the *Idle Parameters* options.

Idle valve type – type of the connected valve (On/Off, PWM, Stepper), or its lack (Disable),
Frequency – frequency of PWM valve or stepper motor,
Stepper steps range – range of the stepper motor steps (you should provide the number of steps),
Reverse – work in the reverse direction (stepper motor), or with the reverse duty cycle
Idle PWM output – output to which the PMW or On/Off valve is connected,
Afterstart RPM increase – value which will be used to increase the engine's speed for a short time after the start-up towards the nominal speed determined in the map of *Idle Target RPM,*
Afterstart duration – it determines what time after start-up the engine will work with the increased idle speed,
Idle On if TPS below - TPS value below which the control of idle speed is turned on,
Idle Off if TPS over - TPS value above which the control of idle speed is turned off,
Increase idle above VSS – vehicle's speed above which the engine will have increased idle speed,
VSS idle increase value – value which will be used to increase the idle speed above the demanded (as *Increase idle above VSS* parameter),

PID CONTROL





Enable PID control – activates PID regulator of the idle speed,

kP, kI, kD - gains of PID kP, kI, kD terms,

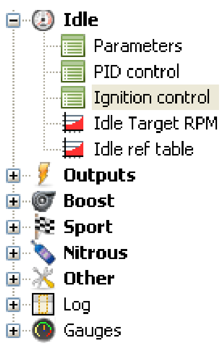
Integral limit+ – maximal positive saturation of the regulator's integrator,

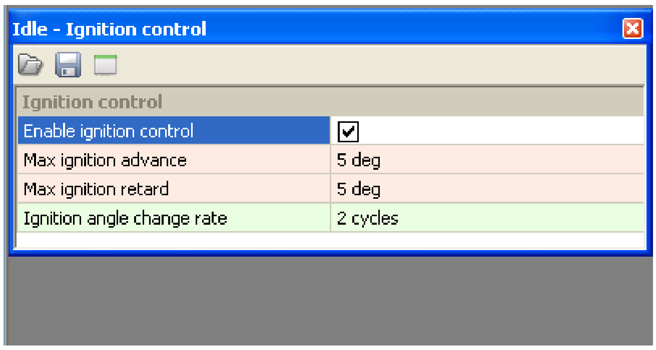
Integral limit- – maximal negative saturation of the regulator's integrator,

Max feedback +, - -maximal value (appropriately „+" and "–„) which can be changed by the regulator in the output DC defined in the table *Idle ref table*,

Deadband RPM – maximal difference between the real engine speed and the one specified in the table of *Idle Target RPM* below which the regulator will not correct the idle speed.

IGNITION CONTROL





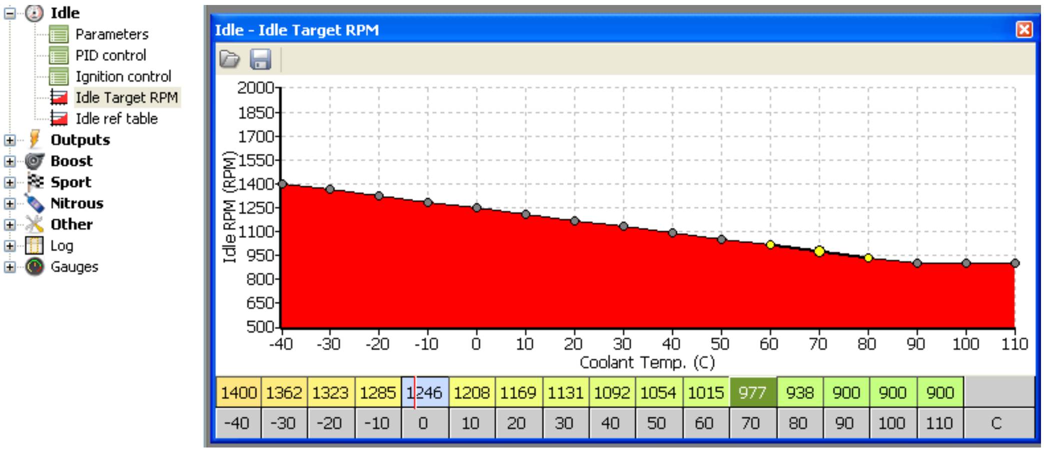
Enable ignition control – activates the modification of ignition angle for the control of the idle speed,

Max ignition advance – specifies the maximal advance of ignition towards the nominal angle resulting from the *Ignition angle* table and correction values,

Max ignition retard – specifies the maximal retard of ignition towards the nominal angle resulting from the *Ignition angle* table and correction values,

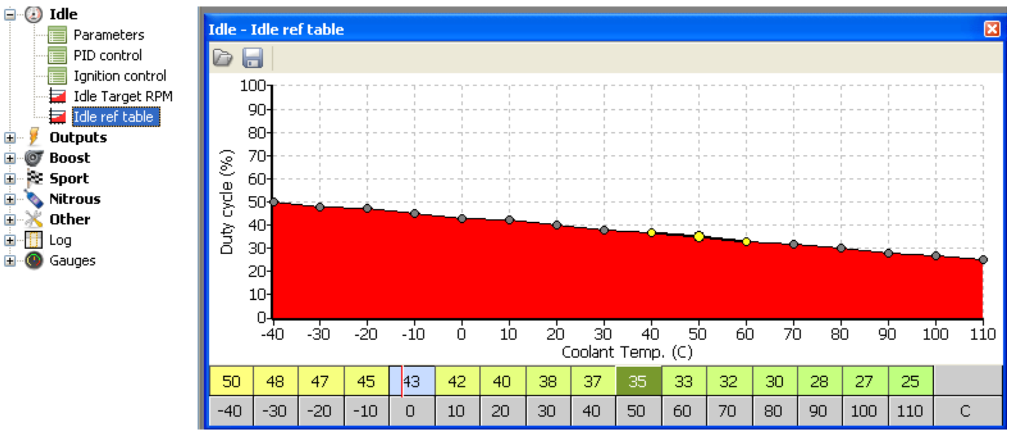
Igntion angle change rate – specifies how often the correction of the ignition angle should be done.

IDLE TARGET RPM



Idle Target RPM table defines the desired idle speed in the function of the cooling liquid temperature. It should be underlined that in order to control idle speed towards this table, it is necessary to activate the PID controller and/or ignition angle controller (*Ignition control*).

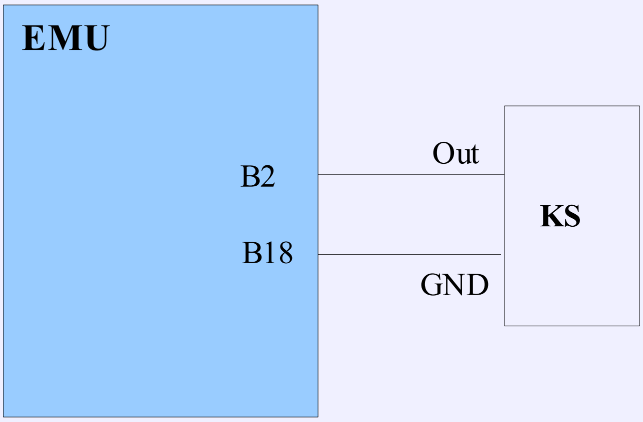
IDLE REF TABLE



The base DC table of PMW valve or stepper motor steps, on which we perform the regulation of idle speed. In case of the stepper motor, the value in this table means the scale of the maximal amount of steps. E.g., 50 means 50% of the *Stepper steps range* value.

CONFIGURATION OF KNOCK SENSORS PARAMETERS

MU device supports knock sensors (two channels) to take actions aiming at avoiding the uncontrolled combustion (by enrichment of the mixture and retard the ignition angle).



Knock sensor sample connection

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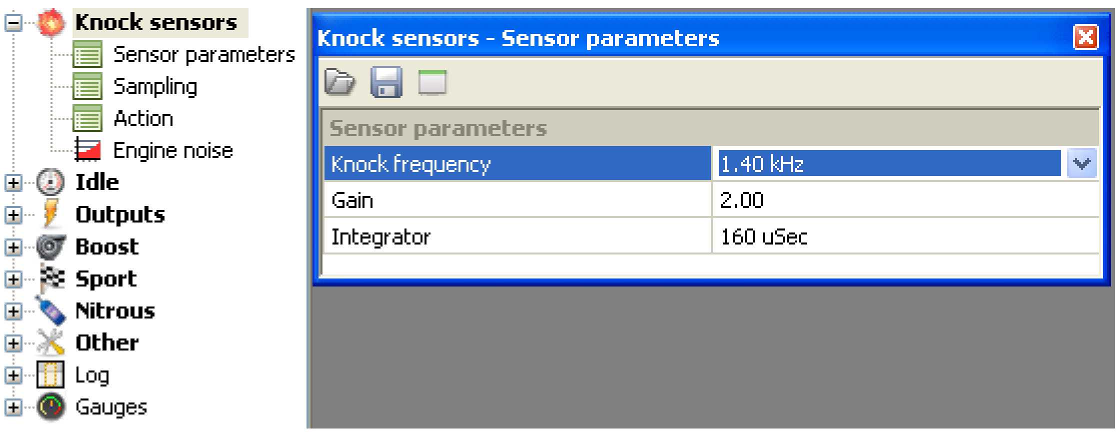
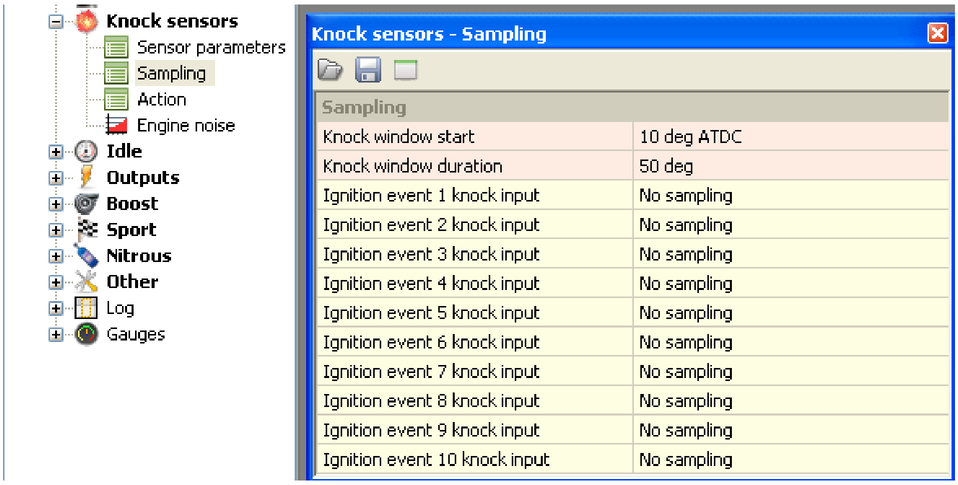
Knock sensors should be connected using cables whith shield connected to the ground at one end.

SENSOR PARAMETERS



Knock frequency – resonant knock frequency. This frequency is characteristic for each engine.
Gain – gain of the signal from the knock sensor. It should be selected so that the value of sensor voltage in the full RPM range with the no knocking does not exceed 3V,**Integrator** – signal's integral time constant from the knock combustion sensor. It influences the voltage value from the knock sensor.

SAMPLING



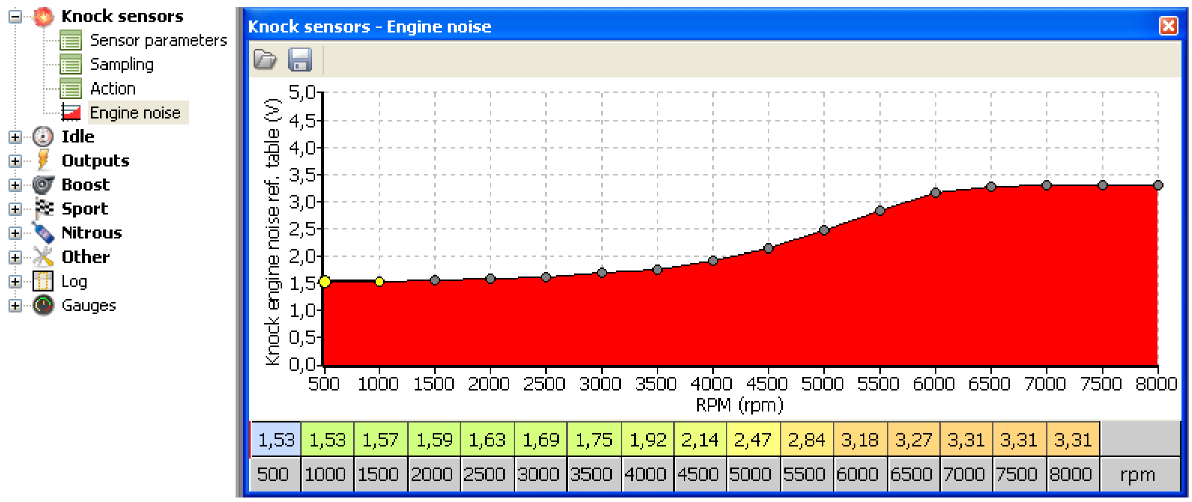
In sampling options we can define the so-called *Knock window* so the range in degrees of crankshaft position, in which may appear the knock combustion. The signal from the sensor is integrated only in this range.

Knock window start – Crankshaft angle measured from the TDC, from which the time window starts,

Knock window duration – determines the time window length in degrees,

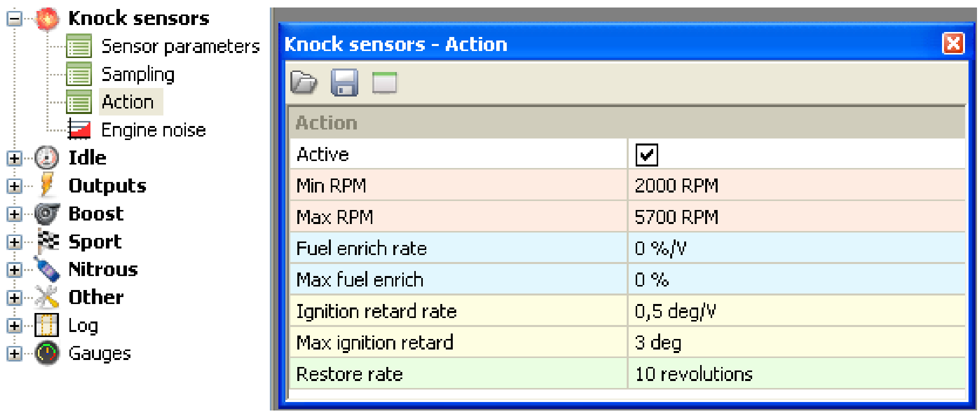
Ignition event 1…10 knock input – defines from which knock sensor input the signal for particular ignition events should be considered (dependency between events, and the order of ignition is defined in *Ignition Outputs*).

ENGINE NOISE



Engine Noise table defines the maximal voltage from the knock sensor for the proper combustion of the mixture in the RPM function. If the voltage from the sensor exceeds the voltage from this table, this will mean the knock occurs. The bigger the difference (*Knock level*), the stronger the knock.

KNOCK ACTION



Knock action defines how the EMU device should behave in case of knock (*Knock level* > 0V).

Active – activates the function of the prevention of the knock ,

Min RPM – minimal engine speed above which the function is active,

Max RPM – engine speed above which the function is deactivated,

Fuel enrich rate – percentage mixture enrichment for each 1V of the *Knock level* value ,

Max fuel enrich – maximal mixture enrichment,

Ignition retard rate – the angle which the ignition is retarded for each 1V of the *Knock level* value,

Max ignition retard – maximal ignition retard,

Restore rate – number of engine revolutions counted from the moment of the knock disappearance, after which the restoration of the nominal fuel dose and ignition advance takes place.

APPENDIX 1 - DESCRIPTION OF LOGGED PARAMATERS

NAZWA PARAMETRU	OPIS
ACC. ENRICHMENT	Percentage value of mixture enrichment connected with *acceleration enrichment.*
ACC. ENRICHMENT PW	Time in ms, which will be used to extend the injection time due to *acceleration enrichment*
ACC. IGNITION CORRECTION	Ignition angle change due to acceleration enrichment
AFR	Value of air to fuel ratio measured with the wide band Lambda sensor
AFR TARGET	Value from *AFR target* table for the given load and engine speed
AFTERSTART ENRICHMENT	Value of after-start enrichment
ANALOG 1	Analog input #1 value
ANALOG 2	Analog input #2 value
ANALOG 3	Analog input #3 value
ANALOG 4	Analog input #4 value
BARO	Value of barometric pressure
BARO CORRECTION	Percentage value of fuel dose correction in the barometric pressure function
BATTERY VOLTAGE	Voltage value from the battery
BOOST CORRECTION	
BOOST DC	Final duty cycle of boost control selenoid valve
BOOST DC FROM TABLE	Duty cycle of boost control selenoid valve from B*oost DC* table
BOOST DC PID CORECTION	Correction of duty cycle of boost control selenoid applied by PID regulator
BOOST TABLE SET	Current boost tables set
BOOST TARGET	Final value of the expected boost pressure
BOOST TARGET FROM TABLE	Value of the expected boost pressure from the *Boost target* table
CAM SIGNAL PRESENT	Information about the signal's presence from the camshaft position sensor on the input CAM 1
CAM SYNC TRIGGER TOOTH	Number of the tooth from the crank position sensor by which the signal from camshaft position sensor takes place
CLT	Coolant liquid temperature value
CLT IGNITION TRIM	Ignition angle correction due to coolant liquid temperature

DWELL ERROR	Error of the real versus desired time of the coil’s dwell timeIgnition angle correction due to
DWELL TIME	Value of the expected coil’s dwell time
EGO CORRECTION	Correction of fuel dose based on Lambda probe readings
EGT 1	Temperature of exhaust gas probe #1
EGT 2	Temperature of exhaust gas probe #2
EMU RESET	Information about EMU reset
EMU STATE	Current device state: **INACTIVE -** device is waiting for the signal from the shaft’s sensor, **CRANKING** - engine’s speed forced by the starter, **AFTERSTART –** *r*unning engine, after-start dose enrichment **RUNING** – engine is working normally
FLAT SHIFT ACTIVE	Flat shift function active
FLAT SHIFT FUEL CUT	Information about fuel cut cased by flat shift
FLAT SHIFT IGN. CUT	Information about spark cut caused by flat shift
FUEL CUT	Information about fuel cut
GEAR	Current gear
GEAR RATIO	Ratio of engine speed and vehicle speed
IAT	Value of intake air temperature
IAT IGNITION TRIM	Ignition angle correction due to intake air temperature
IDLE CONTROL ACTIVE	Idle control active
IDLE IGNITION CORRECTION	Ignition angle correction due to idle speed control algorithm
IDLE MOTOR STEP	Position in steps of idle control stepper motor
IDLE PID DC CORRECTION	Value of DC correction of the valve controlling idle speed introduced by PID algorithm
IDLE TARGET	Required value of idle speed
IDLE VALVE DC	DC value of idle control selenoid valve
IGNITION FROM TABLE	Ignition angle from *Ingition table*
IGNITION ANGLE	Final ignition angle
INJECTORS CAL. TIME	Time form *Injectors cal.* table
INJECTORS PW	Final injectors pulse width
KNOCK ACTION FUEL ENRICHMENT	Percentage value of mixture enrichment in connection to the detection of the knock
KNOCK ACTION IGN. RETARD	Value of ignition angle correction due to occurrence of knock
KNOCK ENGINE NOISE	Voltage value from *Engine noise* table

KNOCK LEVEL	Value of knock (0 if no knock present)
KNOCK SENSOR VALUE	Raw value of voltage from knock sensor
LAMBDA	Lambda value of mixture
LC ACTIVE	*Launch control* function active
LC FUEL ENRICHMENT	Value of mixture enrichment by the *Launch control* function
LC IGN. RETARD	Value of ignition angle correction due to *Launch control function*
MAP	Value of manifold absolute pressure
NITROUS ACTIVE	Active function of controlling the nitrous oxide injection
NITROUS FUEL SCALE	Value of mixture enrichment by functions of controlling the nitrous oxide injection
NITROUS IGN. MODIFICATION	Value of modification of the ignition angle by the function of nitrous oxide control
OVERDWELL	Information about occurrence of overdwell
PARAM. OUTPUT 1	Parametric output #1 active
PARAM. OUTPUT 2	Parametric output #2 active
PWM 1 DC	Duty cycle of PWM #1 output
RPM	Engine speed
SHIFT LIGHT ON	*Shift light* output active
TPS RATE	Rate of change of throttle position
TRIGGER ERROR	Trigger error: **NO ERROR –** correct signal from crank and cam sensors T**OOTH OUT OF RANGE** – tooth number of primary trigger out of predefined range **UNEXPECTED MISSING TOOTH –** unexpected missing tooth on primary trigger input **CAM SYNC ERROR –** cam synchronization error
TRIGGER SYNC STATUS	Ignition synchronisation status: **NO SYNC** – no synchronization **SYNCHRONISING** – trying to synchronizing **SYNCHRONISED –** synchronized. Spark and fuel injection starts to occur
VE	Value of volumetric efficiency from VE table
VEHICLE SPEED	Vehicle speed
VSS FREQUENCY	Frequency of signal from VSS
WARMUP ENRICHMENT	Fuel enrichment due to *Warmup enrichment* table
WBO HEATER DC	WBO heater duty cycle

WBO IP MEAS.	Measured value of WBO IP
WBO IP NORM.	Normalized value of WBO IP
WBO RI	Measured value of WBO RI
WBO VS	Measured value of WBO VS